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Volume 6 (New Series)

Florida and Louisiana Divisions

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PROCEEDINGS
AMERICAN SOCIETY
OF
SUGAR CANE TECHNOLOGISTS

Florida and Louisiana Divisions

VOLUME 6 (NEW SERIES)

May 1977

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PROGRAMS OF ASSCT MEETINGS FOR

1976

PROGRAM OF SIXTH ANNUAL JOINT MEETING
Fort Walton Beach, Florida
June 24-25, 1976

June 24
Morning Session

Registration
Plenary Session - Denver T. Loupe, Presiding

Welcome: Enrique Arias, President, Florida Division

Welcome: P. J. deGravelles, Jr., President, Louisiana Division

Address: The Sugar Scene as Seen from Washington - Horace Godfrey

Report: General Secretary-Treasurer - Denver T. Loupe

General Business Meeting: Denver T. Loupe

Afternoon Sessions

Agricultural Section
Chairman: D. C. Mattingly

Papers Presented:

Saccharum officinarum L. in basic crosses - Houma, Louisiana - P. H. Dunckelman

Factors affecting the seed set of sugarcane - Elias D. Paliatseas

Influence of date of planting on sugarcane variety yields in Louisiana - R. J. Matherne

Genetic behavior of resistance to lodging in progenies of four sugarcane crosses - Howard P. Viator and M. T. Henderson

Stubbling ability in sugarcane varieties - P. M. Lyrene

The effects of skips on sugarcane yield in variety CP 63-588 - B. R. Eiland and P. M. Lyrene

Performance and distribution of commercial sugarcane varieties in Texas - S. A. Reeves, Jr.

Effect of subsoiling on sugarcane production in Louisiana - Ray Ricaud

Yield response of three sugarcane varieties to water table control - Cade E. Carter

Excess water reduces sugarcane yields in Louisiana - Cade E. Carter

Drainage for sugarcane in Louisiana: A review - C. R. Camp, Jr.

Joint Session of Manufacturing and Agricultural Sections
Chairman: Roland Hebert

Papers Presented:

Distribution of carbohydrates in the sugarcane plant - J. E. Irvine

Fiber, specific gravity and mineral content of CP 56-59 and CP 63-588 sugarcane in Florida - G. Kidder, N. I. James and G. J. Gascho

Performance of Polaris as a plant growth regulator on six major sugarcane varieties in Florida during 1975 - Douglas D. Baird

Ripening studies with Glyphosine in Louisiana sugarcane - B. L. Legendre and F. A. Martin

Polaris sugarcane ripener testing in the Rio Grande Valley in 1975 - Norman Rozeff

Freezing, recovery, and deterioration in standing mill cane - B. L. Legendre and J. E. Irvine

A new sugarcane field burner - Chester Fry and Norman Rozeff

Varietal differences in sugar losses with two harvesting methods - B. R. Eiland, J. D. Miller, and G. J. Gascho

An investigation of machine cut sugarcane losses - Norman Rozeff and John Tucker

Use of dynatrol density analyzer in sugarcane juice analysis - F. A. Martin

General aspects of polarimetry and its application in the sugar industry - Manfred F. Nolting

June 25

Morning Session

Agricultural Section
Chairman: Calixto Garcia

Papers Presented:

The mini yield test for sugarcane research - G. T. A. Benda

Micronutrient studies with sugarcane in Louisiana - Laron E. Golden

Estimation of crop conditions and sugarcane yields using aerial photography - J. R. Thomas and G. F. Oerther, Jr.

Artificial inoculation of sugarcane seedling progenies to increase frequency of mosaic resistant clones - R. D. Breaux

Relationship between numbers of diagnostic bacteria and injury by ratoon stunting disease in sugarcane - A. G. Gillaspie, Jr., G. Flax, and H. Koike

Roguing sugarcane mosaic using Glyphosate (Roundup) - Hugh P. Fanguy and Donnie D. Garrison

Aerated steam - Another method of controlling ratoon stunting disease of sugarcane - R. J. Steib, O. M. Cifuentes, B. J. Cochran and M. M. Mayeux

A comparison of the sexual attractiveness, fertility, and fecundity of laboratory reared and wild sugarcane borer adults - J. W. Sanford

Pre and postemergence herbicides in Louisiana sugarcane - Ernest R. Stamper

Controlling browntop panicum in sugarcane - R. W. Millhollon

The susceptibility of Florida sugarcane rats to Diphacinone - Richard C. Ostrowski

Manufacturing Section
Chairman: Carlos Alonso

Papers Presented:

Bagasse conveying - William M. Jacobsz Rosier

Pre-dryer bagasse using flue gasses - J. H. Farinas

The impact of waste-fuel drying on boiler operation, including future boiler design - William P. Boulet

Different approaches to meeting steam requirements in a sugar house - Blas M. Rodriguez and Augusto M. Blanchard

Compromised boiling system with high test raw sugar production - Carlos R. Toca

Capacity determination of continuous centrifugals by purity method - Peter Schubert

Control of particulate emissions with a wet scrubber - William D. Arlington

Bagasse boiler stack cleaning - A. V. Barron, Jr.

Some aspects of industrial water pollution - Robert C. Adams

How practical is the conversion of sugarcane products into fuels and chemical feedstocks? - Edward S. Lipinsky

Energy and our options - A. V. Barron, Jr.

PROGRAM OF 1976 ANNUAL MEETING OF THE FLORIDA DIVISION

Belle Glade, Florida
October 1, 1976

Registration

Welcome: Enrique R. Arias, President

Joint Session of Agricultural and Manufacturing Sections
Chairmen: Calixto Garcia and Carlos Alonso

Papers Presented:

Some promising research areas in sugarcane breeding - P. M. Lyrene

Soil as a factor in Florida sugarcane yields - Gary J. Gascho

Field monitoring to determine economic loss threshold caused by the sugarcane borer, *Diatraea saccharalis* - T. E. Summers, J. R. Orsenigo, and G. Kidder

Assessment of rat damage to Florida sugarcane in 1975 - Lynn W. Lefebre

Mild-growing season burrowing activity and related damage for the Florida Water Rat (*Neofiber alleni*) in a field of sugarcane - D. E. Steffen

Modified 2 1/2 boiling system - Guillermo Aleman

A new approach to evaporator density control - Tom Picard

A sugar travelogue - E. R. Arias, A. R. Mayo, and J. R. Orsenigo

PROGRAM OF 1976 ANNUAL MEETING OF THE LOUISIANA DIVISION

Baton Rouge, Louisiana
February 5-6, 1976

February 5

Registration

Call to Order: J. J. Seip, President

Technical Session
Chairman: Robert L. Allain

Papers Presented:

Variety performance with soldier-type harvesters - Hugh P. Fanguy

Subsurface drainage for sugarcane in Louisiana - Carl R. Camp

Potential for growth regulators in sugarcane - Fred Martin

Engineering aspects of aerated steam heat treating units for control of RSD - Billy J. Cochran

February 6

Technical Session
Chairman: Branan B. Beyt

Papers Presented:

Bagasse drying versus air preheating - Victor J. Bailliet

Core sampling at St. Martin Cooperative - Roland M. Hebert

Computerization of factory operating reports - William H. Thibaut

The fuel and steam balance in the raw sugar factory - Harold S. Birkett

PAPERS PRESENTED AT SIXTH ANNUAL JOINT MEETING

Fort Walton Beach, Florida

June 24-25, 1976

THE SUGAR SCENE AS SEEN FROM WASHINGTON

Horace Godfrey
Godfrey Assoc.
Washington, D. C.

Approximately two years ago, I began a talk with some of you by using the statement "how sweet it is." .Today, as I begin my remarks, I say "it ain't so sweet." All of you know, much too well, what has happened to the price of sugar during the last two years. Recently, we have had some spurts in the market, but the trend is still downward and has now fallen below the cost of production for many cane and beet growers. Crop prospects throughout the world are reported as good with an expected total production which could add to our carry-over stocks. Many people apparently believe that the increased production expected this season will create a sugar surplus. Actually, carry-over stock level, with the increased production, will leave stocks in relation to total use at a lower level than normal. We are not sure what normal carry-over stocks should be and in the opinion of many experts the reserve stocks carried by large and small users decreased immensely during the period when sugar prices were increasing and they have not yet been restored to their former level.

The first question that arises is what can be done to improve the current price situation. There are three actions which, in my opinion, could affect prices. First, legislation creating a sugar act of some kind. I do not believe this is possible during 1976. Second, an international agreement for sugar. There has been much discussion and some meetings with reference to a new international agreement for sugar. The United States has participated in the meetings and discussions to the extent of an "observer." There will be additional meetings held and in my opinion possibly formal discussions early next year. Therefore, nothing in the immediate future in the form of an international agreement. I have personal feelings with respect to an international agreement, but time does not permit a discussion of them at this meeting. Third, action under existing laws. Just recently, Senator Russell Long, (D., LA), chairman of the Finance Committee of the U.S. Senate, wrote President Ford expressing his concern over declining sugar prices and the survival of the domestic sugar industry. In his letter he outlined three actions which could be taken by the President which in his opinion would help maintain the domestic industry, improve sugar prices, and be fair to the consumer. These were: A., increase the present tariff level from 62.5 cents per 100 lb to as much as $1.875 per 100 lb; B., reduce the present foreign import quota of 7 million tons to a more realistic level, (total imports of foreign sugar in 1975 were only 3.9 million tons), and possibly establish individual foreign country import quotas; C., direct the Secretary of Agriculture to establish a price support program for sugarcane and sugarbeets under authority contained in Title 3 of the Agricultural Act of 1949. The level of support could be established from zero to 90% of parity. Senator Long suggested a minimum of 70% in order to be equitable with support levels for other commodities. Seventy percent of parity would result in a price for raw sugar of 18.5 cents per pound.

Now, what will be done? In my opinion, as long as the raw price remains in the general area of 14 cents there will be nothing done. The next question arises then. How far can the price drop? I am not in a position to answer this and don't believe that anyone else can. The size of the European beet sugar crop will be determined to a great extent by weather conditions. Good weather resulting in a good crop will mean lower prices. Bad weather resulting in lower production would mean better prices.

There are some people who are now discussing the inclusion of sugar legislation in the overall farm bill which comes before Congress next year.

To summarize what I have said so far, the immediate future does not look too bright. There will be up and down swings in the market. To maintain a domestic industry we need high yielding varieties and lower production costs. I congratulate those of you in this room on the excellent job you have done over the years in keeping a viable sugarcane industry and in expanding production. You are the ones who have accomplished this.

In my preliminary opening remarks, I indicated that I wanted to discuss something other than the sugar scene. As you recall, I stated that much of the publicity given to our members of Congress with reference to extra-curricular activities was merely a cover-up to prevent us from knowing what was really being done to us by restrictive legislation and regulation. Having been connected with farming for more than a half century, I am seriously concerned about the ability of the American farmer to continue to feed the people of this nation and most of the world. As has been said, American agriculture is no less than a modern day miracle. However, we are being faced with many obstacles in our efforts to increase production and to stay in business. World population is steadily increasing. The chart-makers show the food production and population lines crossing in the mid-80's. That is, until the mid-80's there will be adequate supply to meet population needs, but after the mid-80's, population increase outstrips increase in food production.

As all farmers know, but not many non-farmers realize, farm production depends on many, many things including soil, climate, weather, availability of all other inputs', costs and so forth. In addition, however, farm production also now depends to a major extent on laws passed by Congress or rules and regulations written by bureaucrats. I generally refer to these as "restraints" on production. These restraints have driven and are driving many farmers out of business.

To name a few: a. laws and regulations on clean air; b. laws and regulations on clean water (Incidently, I never cease to be amazed with the lack of knowledge on the part of so-called educated people in what is involved in the production of a farm crop. I refer to these people as "do-gooders." For example, in the current amendments to the Clean Air Act, there is a proposed amendment that says even though the air is of much better quality than required for the protection of the health and welfare of the people that no degradation of that air can take place even though the area involved may be needed to produce food and fiber. Areas with this kind of air are usually national parks or restricted areas. But, the areas adjoining these could not be put to any use which may have the effect of reducing the air quality. As a friend of mine put it, "Is it more important to use the area adjoining to produce food for 5,000 children or keep the air better than necessary so 3 or 4 privileged children can visit the park?"); C. bans on uses of insecticides, herbicides and other chemicals; d. farm labor costs and benefits for farm laborers; E. standards for safety and health (OSHA). (Just think for a moment what OSHA has meant to all of us: roll bars, closed tractor cabs, noise eliminaters, factory inspections and citations, new proposed toilets within five minutes walk for all field workers. And they still find time to spend thousands of dollars to inform us that fresh manure on a cement floor is slick. I could go on with many, many others.); F. land use restrictions.

The list could go on and on and on, but some time soon the general public must be made aware that these restraints may mean hungry people. Somehow, someway, we who are engaged in producing food and fiber must get this simple fact across. If you want to be well fed and well clothed, be careful of the restraints placed on farmers.

MANIPULATION OF PHOTOPERIOD FOR FLOWER CONTROL AND CROSSING OF SACCHARUM OFFICINARUM L.[1]

P. H. Dunckelman
U. S. Sugarcane Field Laboratory
ARS, USDA
Houma, Louisiana 70361

ABSTRACT

There are over 600 clones of the noble species, Saccharum officinarum L., in the World Collection of Sugarcanes maintained by the USDA. Only 9 were used in interspecific hybridization with other Saccharum species to produce the commercial varieties grown in the U. S. subtropics. Since S. officinarum is the donor for sucrose, low fiber, juiciness, and large size of stalks in crosses with other species, particularly the vigorous, disease-resistant S. spontaneum L., an effort is now underway at Houma to use more of this essential but largely untouched source of sugarcane germplasm. In 1974, 13 noble clones were made to flower early by artificially controlling the photoperiod. These clones were crosses in 29 combinations with 3 selected S. spontaneum clones and 10 F_1 selections from S. spontaneum and S. robustum Brandes & Jesw. ex Grassl lines. Over 9000 viable seeds were produced.

INTRODUCTION

Over 600 varieties growing in the World Collection of Sugarcanes are listed as noble canes[2]. The noble designation was coined by Dutch workers in Java in reference to the flamboyant stalk colors and large size of these clones of Saccharum officinarum L.

S. officinarum contributes the sugar storage potential (1, 2, 14) to the interspecific hybrids that presently produce the world's sugarcane crops. This species also transmits to these interspecific hybrids large diameter and stalk weight, self-trashing, low fiber, and juiciness. The nobilization of the commercially worthless but vigorous and disease-resistant S. spontaneum genotype required approximately 25 years and several generations of crossing, selection, and backcrossing.

Chromosome numbers of S. officinarum double when hybridized by S. spontaneum in the F_1 and BC_1 generations (3). Because of this peculiar cytological mechanism, some of the resultant seedlings not only possess many of the characteristics of S. officinarum, but are also disease resistant and adapted to the subtropics (2).

The poor flowering of S. officinarum clones at the higher latitudes, including Louisiana, is a serious deterrent to using S. officinarum in crosses outside the tropics. However, photoperiod treatments used at Houma in 1974 to control the flowering of sugarcane (6) induced S. officinarum 'Fiji 40' to flower simultaneously with other breeding canes. S. officinarum clones, thus induced to flower, can then be crossed with superior S. spontaneum clones (8, 9) and with vigorous early-generation S. spontaneum and S. robustum Brandes & Jesw. ex Grassl lines with resistance to mosaic (10), cold (11), and stalk borers (12, 13).

Very few S. officinarum clones were used in the breeding of hybrid varieties (1, 14). This prompted us in the basic breeding program at Houma (4, 5) to sample more of this little-used but valuable germplasm. The first successful crosses at Houma involving S. officinarum were made in 1974 (7) when Fiji 40 was crossed with the superior S. spontaneum clones Djatiroto and US 56-15-8.

MATERIALS AND METHODS

In October, 1974, single-bud cuttings of 20 clones of S. officinarum (Table 1) were planted in flats of sterilized soil in the greenhouse. In January, 1975, the clones were transplanted to 60 10-gal cans placed on the rail carts of the breeding greenhouse. Three months later, 40 can cultures of the 20 clones were moved from the greenhouse carts onto the carts of the photoperiod house; a single can of each clone was placed on each of 2 photoperiod carts and one can of each was left on the greenhouse carts as controls.

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[1] Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.
[2] 1975 Alphabetical list of sugarcane varieties (USDA).

Table 1. Flowering response of 20 Saccharum officinarum L. varieties to artificial and natural day lengths at Houma, Louisiana, during 1975.

Variety	Fixed day lengths1/			Declining day lengths2/			Natural day lengths3/ (control)		
	Stalks treated (No.)	Stalks flowered (%)	First tassel emergence (Date)	Stalks treated (No.)	Stalks flowered (%)	First tassel emergence (Date)	Stalks treated (No.)	Stalks flowered (%)	Floral initials4/ (%)
Badila	2	0	-	3	0	-	4	0	0
Bambu	3	100	10/16	3	0	-	2	0	100
Cavengerie	2	0	-	3	0	-	5	0	0
Crystalina	3	0	-	3	0	-	2	0	0
D. 74	4	0	-	6	0	-	4	0	0
Fiji 40	5	100	10/14	2	100	10/10	4	0	75
Lahaina	4	100	11/4	2	0	-	3	0	100
La. Purple	3	0	-	3	0	-	4	0	0
La. Stripe	4	0	-	5	0	-	3	0	0
NG 28-2	3	100	11/8	4	0	-	1	0	100
NG 28-14	3	100	10/25	3	66	10/18	2	0	100
NG 28-220	4	0	-	5	20	11/9	4	0	0
NG 28-288	4	75	10/17	4	50	10/12	3	0	100
NG 51-52	6	83	10/24	4	100	10/15	5	0	80
NG 51-144	3	100	10/8	3	100	10/5	3	0	100
NG 51-146	3	100	10/3	3	100	10/2	2	0	100
NG 51-163	3	100	10/9	3	100	10/5	2	0	100
Otaheite	3	100	10/27	4	0	-	2	0	100
SS 58-8	5	0	-	5	0	-	5	0	0
Vellai	2	100	11/2	4	0	-	3	0	100
Total or avg.	69	60	-	72	28	-	63	0	48

1/ 12 hr 25 min daily from June 16 - September 12, 1975.
2/ 12 hr 28 min to 12 hr 00 min from June 16 - September 12, 1975.
3/ Supplemented with night temperature control (20°C) from September 8 - November 1, 1975.
4/ Canes cut open and examined for floral initials as an index of flowering on November 1, 1975.

Concurrently with the planting of the S. officinarum clones, 300 cans were planted with 128 genetic stocks including 28 clones of S. spontaneum, 29 of commercial and near-commercial interspecific hybrids, and 71 new selections from crosses involving commercial x S. spontaneum and/or S. robustum clones. Can cultures of each of the 3 classes of genetic stocks were placed on outdoor racks and on carts of the photoperiod house and breeding greenhouse.

The can cultures were watered, fertilized, and treated with insecticides as needed. Weak suckers and dry leaves were removed by hand, so that only dominant stalks were retained. As the plants grew, they were kept erect by tying them to tie-bars.

Photoperiod treatments with the S. officinarum clones were started on June 16, 1975. The 20 clones in the test were subjected to 2 experimentally controlled photoperiod regimes as well as to natural day lengths on the rail carts of the breeding greenhouse. In Treatment 1, the clones were subjected to a fixed day length of 12 hr 25 min from June 16 to September 12 (89 days). In Treatment 2, the same clones were subjected to day lengths declining from 12 hr 28 min to 12 hr 0 min (1 min every third day) for 89 days. In Treatments 1 and 2, day length was adjusted by varying the sunrise time rather than sunset. In the morning, the canes were moved outside into sunlight precisely at the specified time and back into the photoperiod house at or after sunset. Beginning September 8, the control group on the carts of the breeding greenhouse were rolled indoors at night where the temperature was maintained at about 20°C.

The other genetic stocks were exposed to natural conditions except those on 2 remaining photoperiod carts and on the carts of the breeding greenhouse. Those on the carts were rolled indoors at sunset after September 8 to comply with photoperiod schedules and to protect them from low night temperatures.

When signs of flowering appeared in the S. officinarum clones (and in other genetic stocks), each stalk was air-layered by enclosing 2 nodes in a special soil mixture surrounded by black polyethylene film; every live-rooted flowering stalk was then handled individually at the time of crossing. All crosses were made in the cubicles of the breeding greenhouse.

RESULTS

Treatment 1.

When *S. officinarum* clones were subjected to a fixed day length of 12 hr 25 min for 89 days, tassels of NG 51-146 emerged first on October 3, and those of NG 28-2 last, on November 8, 1975 (Table 1). Twelve of the 20 clones tested were induced to flower. Tasseling was profuse, with all 40 stalks of the 12 clones producing tassels.

Treatment 2.

The 20 *S. officinarum* clones were subjected to day length declining from 12 hr 28 min to 12 hr 0 min (1 min every third day) for 89 days. Only 8 clones flowered (Table 1). Tassels of NG 51-146 emerged first, on October 2, and those of NG 28-220 last, on November 9, 1975. NG 28-220 did not flower in Treatment 1, nor did it produce floral initials in the control group. The 8 nobles induced to flower under the declining day length produced 20 tassels.

Controls

No external signs of flowering, such as short-leafing, booting, or flagging, were observed in any of the 20 *S. officinarum* clones subjected to naturally declining day lengths, with night temperature control, on the carts of the breeding greenhouse from September 8 (12 hr 32 min) to November 1, 1975 (11 hr 0 min). On November 1, the canes were cut from the cans and the growing points of all stalks in the control group were split open and examined for signs of flowering. Floral initials 1/8" to 1/4" long, some aborted, were found in the same 12 nobles that had tasseled earlier, or were about to tassel, in Treatment 1 (Table 1).

Crosses with *S. officinarum* clones.

Among 118 basic crosses made during the 1975 breeding season, 29 involved the use of 13 *S. officinarum* clones (Table 2). The *S. officinarum* clones were used as females and the *S. spontaneum* and *S. robustum* selections were used as males.

Table 2. Noble canes in crosses at Houma, Louisiana, 1975.

Female noble parent	Male Parent			
	S. spontaneum lines		*S. robustum* x *S. spontaneum* hybrids	
	Tassels (No.)	Viable seeds (No.)	Tassels (No.)	Viable seeds (No.)
Bambu	4	0	1	0
Fiji 40	6	802	-	-
Lahaina	2	0	2	0
NG 28-2	1	832	1	812
NG 28-14	3	624	1	-
NG 28-220	1	105	-	-
NG 28-288	4	820	-	-
NG 51-52	7	421	2	1170
NG 51-144	4	880	-	-
NG 51-146	4	413	-	-
NG 51-163	6	2700	-	-
Otaheite	2	0	1	0
Vellai	-	-	2	0
Total	44	7597	9	1982

Many of the *S. officinarum* tassels were in poor condition as a result of being left outdoors during unusually cool weather that persisted after September 21. Some of the male parents, which came from outdoor racks, also were exposed to cool weather until they were moved inside and set in crosses with the *S. officinarum* clones during the period October 7 - November 17. The weakened condition of the tassels was very likely responsible for the generally poor production of viable true seeds from these crosses.

Seed production was obtained with 8 *S. officinarum* clones originally collected in New Guinea (NG) and with Fiji 40. Male-sterile tassels of noble clones from both Treatment 1 and Treatment 2 were observed to produce viable seeds. The poorest performance was shown by 'Bambu', 'Lahaina', 'Otaheite', and 'Vellai' (Table 2). The highest seed set (832 per tassel) was obtained from a cross in which NG 28-2 was the female and US 72-41 the male. US 72-41 is an F_1 from a cross between L 60-25 and *S. spontaneum* SES 6. The total number of seeds produced by all of the crosses involving *S. officinarum* was estimated to be 9579.

DISCUSSION

Clones of S. officinarum, the tropical species, have never been known to flower under natural conditions at Houma, Louisiana (L 29°35'N).

In 1975, a significant step in the basic breeding work was achieved when 13 S. officinarum clones were made to flower early by artificially controlling the photoperiod. Under fixed day lengths of 12 hr 25 min (89 days), 12 of the 20 clones in the test flowered early. Under declining day lengths of 12 hr 28 min to 12 hr 0 min (89 days), 8 of the 20 clones were induced to flower. Clones under declining day lengths flowered somewhat earlier than those under fixed day lengths. Flowering in both treatments occurred between October 3 and November 11, 1975.

On November 1, no external signs of flowering were apparent in the control group. However, internal examination revealed the presence of floral initials, some aborted, in the same 12 noble clones that had already flowered or were about to flower under artificially fixed day lengths. A few tassels from the stronger stalks in the control group might have emerged if left for several months. However, flowering would certainly have occurred too late to cross with the early flowering S. spontaneum clones and those of the early-generation S. spontaneum and S. robustum selections from new breeding lines.

Work with the S. officinarum species is continuing, and it is anticipated that more of this essential germplasm will be used in crosses to broaden the genetic base and to develop new high-yielding sugarcanes for the subtropics.

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FACTORS AFFECTING THE SEED SET OF SUGARCANE

Elias D. Paliatseas
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

The number of seedlings produced annually at Baton Rouge, Louisiana, from bi-parental crosses were between 200,000 and 300,000. Although the number of seedlings per tassel or the number of seedlings per gram of fuzz did not vary very much, on the average, from year to year, the number of seedlings per tassel between and within crosses varied tremendously. The differences were due to the amount and viability of the pollen available and to the degree of sexual compatibility between varieties. The factors affecting the production and viability of pollen affect the seed set as well. One of these factors is temperature; under temperatures of 80-85 F (day) and 70-75 F (night), a maximum seed set per tassel or per gram of fuzz is achieved. Under temperatures of 70-75 F (day) and 60-65 F (night), the seed set per tassel was substantially lower, while, under temperatures of 60-65 F (day) and 50-55 F (night), the seed set per tassel was practically zero. Under favorable temperature conditions for pollen production, i.e., temperatures of 80-85 F and night temperatures of 70-75 F., there were some variations in seed set per tassel due to pollination practices and to the way the tassels of sugarcane are grown or preserved. During the time the anthers open up, one or two pollinations were enough for a maximum seed set per tassel. However, two or three pollinations before or after the opening of the anthers resulted in a considerably lower seed set per tassel.

INFLUENCE OF PLANTING DATE ON SUGARCANE VARIETY YIELDS IN LOUISIANA[1]

R. J. Matherne
U. S. Sugarcane Field Laboratory
ARS, USDA
Houma, Louisiana 70361

ABSTRACT

The commercial sugarcane varieties CP 61-37, L 60-25, L 62-96, L 65-69, and CP 65-357 were tested to determine their response in yield of tons of cane per acre, theoretical recoverable sugar per ton, and recoverable sugar per acre for August 15, September 1, and October 1 plantings. A significant interaction occurred between varieties and yield of cane and sugar per acre at different planting dates. Data from 4 years of testing showed that CP 61-37 yielded the same in tons of cane per acre for all planting dates. L 60-25 yielded significantly better when planted in August than when planted in October, and the September planting ranked between the August and October planting dates but was not significantly different from either. L 62-96 yielded significantly better when planted in August than when planted in September or October. One year's data with CP 65-357 and L 65-69 also showed interaction. September and October planting of CP 65-357 showed the highest yields of cane per acre. L 65-69 yielded about the same for all planting dates. CP 61-37 was the only variety with significantly higher sugar per ton yield due to early planting.

INTRODUCTION

Planting dates of Louisiana sugarcane have changed through the years with the introduction of new varieties and improvements in cultural practices. The noble varieties, Saccharum officinarum L., were planted in the spring. Cane to be planted was cut in the fall before a killing freeze, laid down between the rows, and covered with leaves and/or soil. This practice, called windrowing, was used to protect the cane from the winter freezes. Some windrowed cane was sent to the mill but a sufficient quantity was kept for seed to plant the next crop the following spring. During the mid 1920's and early 1930's the POJ, Co, and CP varieties were introduced (interspecific hybrids of Saccharum sp.) which were generally more tolerant to cold and less desirable for windrowing. These varieties generally responded best to fall or summer plantings. Arceneaux (1, 2) found that among these varieties there was an interaction between planting dates and yields of cane per acre the next year. He reported that varieties POJ 213, POJ 234, and POJ 36 M yielded best when planted in October or early November, but varieties Co 290, Co 281, CP 807, and CP 28-19 yielded best when planted in early August. During the early 1930's there was a major shift from spring to fall planting (3).

Matherne (5) reported in 1964 that CP 44-101, CP 52-68, CP 55-30, and NCo 310 responded best to September planting. CP 52-68 made its lowest yield with October planting, and CP 55-30 was lowest with August planting.

Excessive rainfall during normal planting periods can prevent growers from completing their planting as scheduled. In recent years, a return to spring planting as a means to complete planting of the crop has been considered. With windrowing no longer considered feasible, Fanguy and Benda (4) spring-planted cane imported from Florida. However, yields of cane per acre were considerably below those of cane of the same variety planted in the fall.

Changes in varietal utilization (6) are continuous, and prior testing (1, 2, 5) has indicated that varieties react differently to dates of planting. Data on date of planting for the current leading commercial varieties are summarized in this report and preliminary data on the newer varieties are given.

MATERIALS AND METHODS

Three commercial sugarcane varieties, CP 61-37, L 60-25, and L 62-96, were included in date of planting experiments in 1968, 1969, 1973, and 1974. In 1972, the varieties L 60-25, L 62-96, L 65-69, and CP 65-357 were planted. No experiments were initiated in 1970 and 1971 due to excessive rainfall in August and September. In every experiment, 3 dates of planting were made: August 15, September 1, and October 1. Harvest occurred in early December in the year immediately following planting.

All experiments were conducted on mixed alluvial soil (Mhoon silt loam) at the Houma Sugarcane Laboratory. The split-plot design was used with varieties as the main plot factor and the planting dates as the subplot factor. Subplots were 1/120 acre and replicated four times. All plots were cut by hand and weighed with a hydraulic tractor-mounted scale. Fifteen-stalk samples were pulled, weighed, and milled for stalk weight and juice quality analyses. Data from field weights and juice quality were used to calculate yield of tons of cane per acre, theoretical sugar per ton of cane, and sugar per acre. All data were analyzed using the analysis of variance.

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[1] A contribution from the Southern Region, ARS, USDA in cooperation with the Louisiana Agricultural Experiment Station.

RESULTS AND DISCUSSION

The average yields of CP 61-37, L 60-25, and L 62-96 for the 4 years are found in Table 1.

Table 1. Average yields in the plant cane crop with 3 varieties for the years 1969, 1970, 1974, and 1975.

Date	Varieties		
	CP 61-37	L 60-25	L 62-96
	Yields of cane per acre (tons)		
August 15	40.2 ab[1]	38.8 ab	41.7 a
September 1	39.7 ab	36.8 bc	32.0 d
October 1	38.9 ab	34.3 cd	35.0 cd
	Yields of sugar per ton of cane (lb)		
August 15	224 b	237 a	247 a
September 1	219 bc	241 a	246 a
October 1	211 c	238 a	247 a
	Yields of sugar per acre (lb)		
August 15	9005 b	9196 b	10300 a
September 1	8694 bc	8869 bc	7872 c
October 1	8208 bc	8163 bc	8645 bc

[1] Means followed by the same letter are not significantly different at the 5% level of probability.

CP 61-37 showed no significant differences in yields of cane per acre for the 3 planting dates. The August and September planting dates of CP 61-37 did show an increase in sugar per ton yield. Arceneaux (2) reported similar responses with varieties Co 281, Co 290, and CP 807.

L 60-25 and L 62-96 responded best to the August planting in yields of cane per acre. These varieties showed no differences in yield of sugar per ton due to planting dates.

Table 2 shows the yield of the more recent commercial varieties L 65-69 and CP 65-357. Yields in tonnage for L 65-69 were not significantly different for the 3 planting dates. CP 65-357 had significantly better cane per acre yields with the September and October plantings. L 65-69 and CP 65-357 showed no significant differences in sugar per ton yields due to planting dates.

Table 2. Average yields of plant cane crop with 4 varieties during 1973.

Date	Varieties			
	L 60-25	L 62-96	L 65-69	CP 65-357
	Yields of cane per acre (tons)			
August 15	36.7 bc[1]	38.1 b	33.0 d	29.6 e
September 1	38.1 b	22.4 f	33.2 d	37.1 b
October 1	33.9 cd	29.6 e	35.4 bcd	42.7 a
	Yields of sugar per ton of cane (lb)			
August 15	256	262	246	261
September 1	259	247	261	256
October 1	259	264	266	274
LSD .05	NS	NS	NS	NS
	Yields of sugar per acre (lb)			
August 15	9395 bc	9982 b	8118 cd	7726 d
September 1	9868 b	5533 e	8665 bcd	9498 bc
October 1	8780 bcd	7814 d	9416 bc	11700 a

[1] Means followed by the same letter are not significantly different at the 5% level of probability.

The yields of cane per acre are illustrated graphically in Fig. 1. L 62-96 showed a tremendous advantage from August planting. CP 65-357 showed a tremendous advantage from October planting. Moderate advantage was gained in August planting with L 60-25, and CP 61-37 responded equally well at all planting dates.

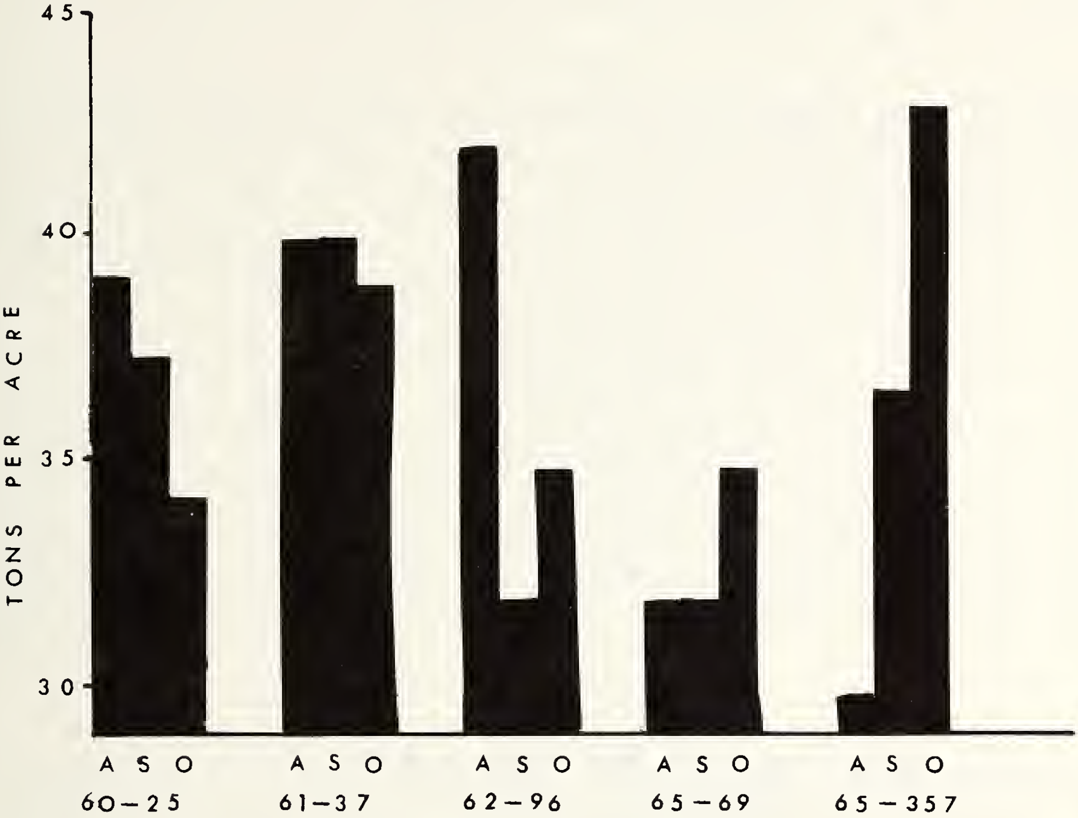

Fig. 1. Effect of date of planting on yield of cane per acre.

Prevailing weather conditions at planting complicate interpretation of date of planting experiments. Therefore, several years of testing are necessary before any conclusions can be made regarding optimum planting dates.

It is standard practice to begin planting in Louisiana during August. Results from these experiments indicate that CP 61-37, L 60-25, and L 62-96 are well-suited to August planting. August planting of L 62-96 is almost mandatory if good yields in the plant cane crop are to be obtained. A secondary benefit from planting CP 61-37 early is the apparent increase in juice quality at harvest. However, this early planting is sometimes limited due to the high rainfall during August.

The varieties L 60-25, CP 61-37, and CP 65-357 yield well when planted in September. Most years' climatic conditions are more favorable to September planting than to August and October planting.

The varieties best suited for October planting are CP 65-357, L 65-69, and CP 61-37. Growers' experience is in agreement with preliminary data of CP 65-357 and indicates that this variety is not adapted to early planting.

These results follow closely the pattern obtained by previous investigators (1, 2, 5). A significant interaction occurred between varieties and yield of cane per acre, yield of sugar per ton, and yield of sugar per acre at different planting dates. Therefore, if a grower is to attain maximum yield from the present and future varieties, he must follow a definite planting schedule for individual varieties.

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GENETIC BEHAVIOR OF RESISTANCE TO LODGING IN PROGENIES OF FOUR SUGARCANE CROSSES[1]

Howard P. Viator and M. T. Henderson
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana 70803

ABSTRACT

A study of the genetic behavior of resistance to lodging in sugarcane was conducted from 1973 to 1975. In the experiment, 100 randomly chosen clones from the progenies of each of four biparental crosses, along with six replications of the parental clones, were grown in 10-foot clonal plots. Prior to harvest each year, each plot of the clones of the progenies and the parents was classified for lodging by a newly devised system based on a visual estimate of the percentage of severely lodged stalks. Other traits for which data were taken were stalk length, stalk weight, stalk diameter, estimated fiber percent in cane, and juice quality. The data clearly indicate that crosses involving erect parents produce the highest frequency of erect segregates. Unlike a typically quantitative trait, the frequency distribution in percent lodging for the progenies derived from the four crosses did not fit a normal curve. In fact, all lodging classes tended to have similar numbers of segregates. There was some evidence, although it was not statistically significant, that transgressive segregation occurred since 19% of the clones in the progenies was outside the ranges of the parental clones. The average value of the correlation coefficient between percent lodging in one year and the mean percent lodging of both years was a positive, highly significant .84. This is an indication of heritability and suggests that selection of erect clones from small, unreplicated clonal plots in a single season would be reasonably effective. Since only 20% of the clones erect in a normal lodging year was also erect the following year, in which a hurricane occurred, it is evident that selection under normal lodging conditions would not be effective in identifying those clones that would remain erect after severe lodging has occurred. However, the data indicate that extremely decumbent clones could be effectively discarded on the basis of a single year's data. An undesirable positive association was found between lodging and stalk length. As expected, there was a measurable tendency for the tallest clones in the progenies to display the greatest lodging. This emphasizes the need for early selection for erectness. No association was found between erectness and stalk diameter, estimated fiber percent in cane, brix, or sucrose.

INTRODUCTION

Since the advent of the soldier-type harvester in Louisiana, stalk erectness has been of utmost importance to the sugar industry. Recent advances in harvest machinery may eventually remove the requirement for rigid selection for erectness and thus provide greater latitude for selection of agronomic traits. However, at present growers need erect varieties because of the detrimental effect that lodged cane has on juice quality and harvestability.

Several researchers (2, 3, 5, 7, 8) have shown heritability of stalk erectness to be low and have concluded that rigid selection for lodging resistance either among seedlings or among clones in one season would be ineffective.

Breaux (1) concluded, after investigating the effectiveness of selection for erectness as practiced in the breeding program, that efforts to increase the frequency of erect clones were effective only if selection was practiced in clonal plots not severely lodged by wind and rain.

Past research (1, 5, 6) has provided data indicating undesirable associations between stalk erectness and stalk diameter, weight, and length.

Unselected progenies of 4 biparental crosses were grown from 1973 to 1975 to gather data that would provide information on the manner in which erectness is inherited in order to determine the effectiveness of selecting for that trait. An additional objective was to identify any association between erectness and certain other characters which might hinder the ease by which erect varieties could be developed.

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[1] The assistance of the American Sugar Cane League, members of the U. S. Sugarcane Laboratory, Houma, La., and the Louisiana Agricultural Experiment Station, Baton Rouge, La., made this research possible.

MATERIALS AND METHODS

The materials used in this study included the unselected progenies of 4 biparental crosses. The 4 biparental crosses--CP 65-357 x CP 62-258, L 60-25 x CP 66-346, CP 52-68 x L 65-69, and CP 65-357 x L 65-69--were grown as plant cane, first stubble, and second stubble.

The materials were obtained from the U. S. Sugarcane Laboratory in Houma, Louisiana. In the fall of 1972, 100 single stools were chosen from each of the 4 crosses. A 10-foot unreplicated clonal plot was established from each of the 400 single stools at the St. Gabriel branch of the Louisiana Agricultural Experiment Station. Six replications of each of the 8 parental varieties were scattered among the plots of the experimental clones.

Each year the clonal plots were classified by a system that was described in a paper presented at the 1974 Joint Meeting of ASSCT (9). This system, termed the % lodging system, consisted of a visual estimate for each plot of the percentage of stalks which were lodged, with lodged stalks defined as those which lean from the completely upright or vertical position by at least 45 degrees.

For all years, data were obtained for stalk erectness and for certain years data were recorded for laboratory brix, sucrose, mean stalk length, mean stalk weight, mean stalk diameter, and estimated fiber percent in cane by the procedure described by Henderson et al. (4).

RESULTS AND DISCUSSION

On September 7, 1974, Hurricane Carmen caused early and severe lodging among the plots in the first stubble crop. However, the relative behavior of the parents later in the year was in general agreement with the normal lodging behavior of 1973. Because of the agreement in relative behavior of the parental varieties during 1973 and 1974, it was felt that averaging the 2 years for the purpose of interpreting the behavior of the progenies would provide a more accurate evaluation of the inheritance of lodging behavior. Therefore, mean erectness as an average of 1973 and 1974 was obtained for the parents and progenies of the crosses and frequency distributions of these are presented in Tables 1 through 4.

Table 1. Frequency distributions in % lodging classes for the parents, CP 52-68 and L 65-69, and the experimental clones as a mean of the plant cane crop in 1973 and the first stubble crop in 1974.

	No. of clones and percent of progeny in each of the following % lodging classes												
Population	0	10	20	30	40	50	60	70	80	90	100	Total	Mean
CP 52-68	3	3										6	7.5
L 65-69						1	1	3	1			6	69.2
Progeny (no.)	8	7	17	10	15	12	3	7	4	3	2	88	40.3
Progeny (%)	9	8	19	11	17	14	3	8	5	3	2		

Table 2. Frequency distributions in % lodging classes for the parents, L 60-25 and CP 66-346, and the experimental clones as a mean of the plant cane crop in 1973 and the first stubble crop in 1974.

	No. of clones and percent of progeny in each of the following % lodging classes												
Population	0	10	20	30	40	50	60	70	80	90	100	Total	Mean
L 60-25					1	1	3	1				6	61.7
CP 66-346		1	3	2								6	24.2
Progeny (no.)	4	8	11	11	12	14	7	8	3	3	2	83	44.3
Progeny (%)	5	10	13	13	14	17	8	10	4	4	2		

Table 3. Frequency distributions in % lodging classes for the parents, CP 65-357 and CP 62-258, and the experimental clones as a mean of the plant cane crop in 1973 and the first stubble crop in 1974.

	No. of clones and percent of progeny in each of the following % lodging classes												
Population	0	10	20	30	40	50	60	70	80	90	100	Total	Mean
CP 65-357		1	2	2				1				6	32.5
CP 62-258			1		2	1	2					6	46.7
Progeny (no.)	6	7	6	7	9	8	8	4	10	3	8	76	52.5
Progeny (%)	8	9	8	9	12	11	11	5	13	4	11		

Table 4. Frequency distributions in % lodging classes for the parents, CP 65-357 and L 65-69, and the experimental clones as a mean of the plant cane crop in 1973 and the first stubble crop in 1974.

	No. of clones and percent of progeny in each of the following % lodging classes												
Population	0	10	20	30	40	50	60	70	80	90	100	Total	Mean
CP 65-357		1	1	3			1					6	32.5
L 65-69					2				4			6	69.2
Progeny (no.)	5	7	7	6	10	16	9	10	10	8	4	92	54.4
Progeny (%)	5	8	8	7	11	17	10	11	11	9	4		

Unfortunately, due to the very light lodging in 1975, the behavior of the parental varieties did not provide adequate distinction between lodging types nor was it related to their behavior in the 2 previous years. Therefore, it was decided that the 1975 data should not be included with the 1973 and 1974 data and is not reported here.

Similar to their behavior under long-term observations, the varieties ranged in lodging behavior from resistant to susceptible. CP 52-68 was the most resistant variety, CP 65-357 and CP 66-346 were moderately resistant, CP 62-258 was moderately susceptible, and L 65-69 and L 60-25 were susceptible to lodging.

It is apparent, as other workers have indicated, that inheritance of lodging resistance is quantitative in nature. The frequency distributions exhibited certain features that are typical of quantitative traits. Both the replications of the parental clones and the randomly selected experimental clones did not occur in a few qualitative classes but occurred in a large number of continuously varying classes, indicating a strong environmental influence.

Although the variation among the phenotypic classes was indicative of a quantitative trait, the frequency distributions of the progenies exhibited certain features uncharacteristic of a normal distribution. For no cross did the population fit a normal curve. In fact, all lodging classes tended to have similar numbers of segregates.

In 3 of the crosses the progeny mean was intermediate to the parental means and essentially the same as the arithmetic average of the 2 parental means, whereas in 1 cross (Table 3) the progeny mean was higher than either parent. There was a tendency in the progenies for the frequency of clones susceptible to lodging to exceed that of resistant clones. As an average of all crosses, 55% of the experimental clones were above the arithmetic average of the 2 parents in % lodging.

For each cross an analysis of variance, using 1973 and 1974 as replications, revealed that there were no experimental clones either significantly superior in erectness to the mean of the more resistant parent or significantly inferior to the mean of the more susceptible parent.

However, despite the lack of statistical support for transgressive segregation, it is evident that there were some clones among the progenies that were equal to or lower than the most erect parent in % lodging. Nineteen percent of the clones in the progenies was outside the range of the parental clones. There were over twice as many segregates above the range of the more susceptible parent than below the range of the more erect parent.

The data suggest that the lodging tendencies of the progenies was influenced strongly by the lodging behavior of the parents. In general, the parents with the lowest means tended to produce the highest frequency of erect segregates. This can be shown by the fact that the cross CP 52-68 x

L 65-69 (Table 1) had over 10% more segregates exhibiting 20% or less lodging than the cross CP 65-357 x L 65-69 (Table 4), indicating the superiority of an erect parent over a moderately erect parent in the ability to transmit genes for erectness to the progeny.

In order to obtain an indication of heritability, or the proportion of the total variation that is genetic in nature, correlation coefficients between erectness classification values in 1973 and 1974 were calculated. The r value as an average of all crosses was .41. This positive, highly significant r value indicated a moderate agreement, meaning that there was a moderate tendency for clones exhibiting a particular behavior in 1 year to exhibit the same behavior in the other year.

However, it is evident from this correlation coefficient that limited success would be realized from selection of erect clones based on 1 year's results. For a more accurate indication of heritability, correlation coefficients between erectness classification values of clones in individual years and the mean erectness classification values of both years were calculated for each cross. The average r value for all crosses between % lodging in either year and the mean % lodging of both years was a positive, highly significant .84. This high indication of heritability suggests that selection of erect clones from small, unreplicated clonal plots in a single season would be reasonably effective.

An additional measure of the effectiveness of selection based upon 1 season's results is a comparison of the frequency of erect clones of the entire progeny to the frequency of erect clones of a selected progeny. Of the 339 clones tested in the 4 unselected progenies, 74 clones, or 22%, had 20% or less lodged stalks as an average of both years, 1973 and 1974. If selection had been practiced among the clones of the plant cane crop in 1973 for all clones with 20% or less lodged stalks, 200 clones would have been acceptable. Of these 200 clones, 73 were also acceptable as an average of both years. Therefore 37% of the segregates selected in 1973 would have been acceptable as an average of both years. This represents a net gain of only 18% for the selected progeny over the unselected progeny.

The negligible gain from selection in 1973 was apparently due to the fact that many susceptible clones in the progenies failed to lodge despite their susceptibility.

A far greater gain of 70% would have been realized if selection had been practiced in the first stubble crop in 1974. Since 70% of the clones erect in 1974 were considered erect as an average of both years, it is evident that most clones which remained erect after severe lodging occurred possessed resistant genotypes.

Furthermore, closer examination of the data revealed that selection under normal lodging conditions would not be effective in identifying those clones that would remain erect after severe lodging has occurred. As an average of the progenies of the 4 crosses, only 20% of the clones erect in the normal lodging year of 1973 were erect the following year in which a hurricane occurred. On the other hand, since 95% of the unacceptable clones in the normal lodging year were considered unacceptable the following hurricane year, it was concluded that clones decumbent under normal lodging conditions would also be decumbent after severe lodging has occurred, and could, therefore, be effectively discarded.

Associations, as determined by correlation coefficients between % lodging and other important economic characters, were determined. Table 5 contains the correlation coefficients for the 4 crosses between the average % lodging of 1973 and 1974 and several other economically important characters.

As can be observed in Table 5, the r values between % lodging and stalk diameter, estimated fiber percent in cane, and juice quality components were neither significant nor indicated an important degree of association.

Table 5. Correlation coefficients between % lodging and several other economically important characters measured for the clonal plots of the 4 crosses.

Characters correlated with % lodging	Correlation coefficients for cross no.			
	1	2	3	4
Stalk length	.24*	.31**	.24*	.32**
Stalk diameter	-.17	.14	.15	.13
Stalk weight	.11	.35**	.33**	.31**
Estimated fiber % in cane	.02	.11	.08	-.08
Brix	-.19	.04	-.14	-.09
Sucrose	-.16	.05	-.12	-.10

*Significant at the 5% level of probability.
**Significant at the 1% level of probability.

The r values obtained between % lodging and stalk length (.24 to .32) were positive, significant and indicated that there was a moderately low tendency for taller clones to lodge more than shorter clones. This association between mean stalk length and % lodging could cause difficulty, especially if major emphasis is put on the selection of very tall clones in the early test stages. However, simultaneous selection for both low % lodging and acceptable stalk length should overcome the difficulty.

Correlation coefficients for the 4 crosses between % lodging and stalk weight (.11 to .35) were positive, ranged from nonsignificant to highly significant, and suggest, for 3 crosses, that clones with heavier stalks tend to lodge more than lighter clones. However, it is interesting to note that, since the 2 components of stalk weight are stalk length and stalk diameter, the lack of association between stalk diameter and % lodging (-.17 to .15) suggests that the positive weight-% lodging association is due for the most part to the positive length-% lodging association. This indicates that little consideration need be given to stalk weight in conjunction with selection for erectness. Attention should be directed instead to stalk length.

It was concluded that there would be no difficulty in selecting erect clones which have desirable stalk diameter, length, weight, brix, or sucrose, provided attention is given simultaneously to stalk length and erectness.

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STUBBLING ABILITY IN SUGARCANE VARIETIES

P. M. Lyrene
Agricultural Research and Education Center
Florida Agricultural Experiment Station
Belle Glade, Florida

ABSTRACT

Two methods of estimating stubbling ability in sugarcane were tested on varieties whose actual stubbling abilities were known from field tests. The first method was based on measurements of shoot growth, root growth, and root/shoot ratio of plants grown from one-bud sets in greenhouse pots. Good stubblers generally produced higher shoot weights, root weights, and root/shoot ratios than the poor stubblers, but the method did not appear to distinguish well enough among varieties to be practical. For the second method, field plots were cut at ground level four times at monthly intervals and the dried forage was weighed. This method revealed enormous differences among test varieties, with the highest-yielding variety averaging nearly 400% of the lowest. Varieties which were the best stubblers under conditions of commercial sugar production produced the highest yields of dried forage.

THE EFFECT OF SKIPS ON SUGARCANE YIELD IN VARIETY CP 63-588

B. R. Eiland and P. M. Lyrene
USDA, ARS
and
University of Florida, AREC
Belle Glade, Florida

ABSTRACT

An experiment was conducted to determine the effect of skips on sugarcane yield and the extent of yield compensation in areas adjacent to skips. Results showed that skips up to 3 m long did not lower gross cane yields. An increased number of stalks at each end of a skip with an increase in stalk growth in areas adjacent to skips appeared to compensate for yield losses associated with skip areas.

INTRODUCTION

All sugarcane growers would like to obtain continuous stands of cane from planting. In Florida, continuous stands of cane are obtained by hand planting if planting conditions are normal, if planting rates are varied according to the season and cane variety, and if the cane is planted carefully. On the other hand, mechanical planting introduces skips of varying lengths, depending upon the operator's skill, the seed harvesting method used, and the metering characteristics of different varieties.

Skips in sugarcane fields tend to appear after the first harvest due to uprooting by field traffic, stubble removal by harvesting equipment, cold damage, and many other factors. Removal of stubble by mechanical harvesters is a major cause for skips, and, as a consequence, the number of seasons that a field can be harvested is reduced when mechanical harvesters are used. Field are normally replanted after three to five harvests due to reduced yields caused by skips. Several producers utilize skip planting so they can prolong stubble life and so they can keep workers employed on an annual basis.

Arceneaux and Stokes (1) showed that skips in plant cane influence yield more than skips in ratoon crops and that yield compensation for a given skip length varies by variety. Florida producers have little data from which to estimate the effect of skips on yield. The purpose of this study was to determine the effect of skips on plant cane yield in variety CP 63-588 and the degree of yield compensation that occurs in areas adjacent to skips.

METHODS AND MATERIALS

The variety used in this experiment was CP 63-588, currently Florida's most widely grown variety (3). Seed cane was harvested with a Massey-Ferguson chopper harvester on March 17, 1975. Seedpieces up to 60 cm long were obtained by removing one set of chopping blades from the harvester. For the experiment these pieces were planted in two continuous lines, except in skips. Treatment plots were 6.4 m wide, 10 m long, and contained four rows. Plots were arranged in a randomized complete block design, with four replications. Each block consisted of five skip treatments and a check treatment without skips. For the skip treatments, skips from 1 to 5 m long were left in opposite ends of the two center rows, called skip rows, in each plot as shown in Fig. 1. The two outside rows of each plot will be referred to as border rows.

About 1 week before harvest, we counted the millable stalks in each row of each plot to determine whether additional tillering increased the stalk population. Row populations per hectare were calculated from the row counts for border rows and skip rows. We tested border- and skip-row population means for differences, using Duncan's Multiple Range Test (4). Densities, based on skip-row length planted, were calculated from the skip-row counts. We tested the mean of the skip-row densities for each skip treatment with the mean of the row density in the check treatment for differences using a one-tailed t-test for two sample means (4). The additional stalks in each skip row over the equivalent length of check row were calculated for each skip row, averaged over each treatment, and averaged over the five skip treatments.

Internodal stalk diameters, about 1.5 m above the ground level, were measured in all rows bordering skips about 1 week before harvesting. The diameters of 10 random stalks were measured in border-row areas adjacent to skips, and the diameters of 10 other random stalks were measured in border-row areas away from skips. The average diameters of the stalks in areas adjacent to skips and of the stalks in areas away from skips were calculated for each plot. We tested these diameters for differences, using a paired t-test (4).

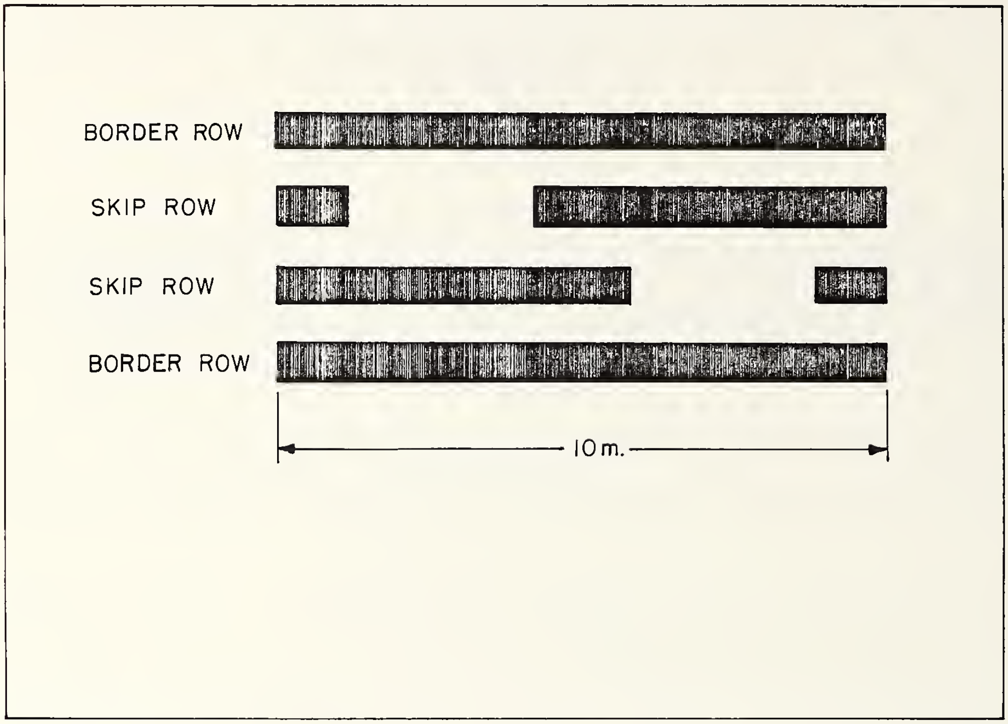

Fig. 1. Diagram showing distribution of 3-m skips (light area) in a four-row plots, 10m long.

The cane was burned 1 day before harvesting began. Immediately before harvesting, three random wholestalk samples, each containing five stalks, were taken from border-row areas adjacent to skips, along with three samples from border-row areas away from skips, for milling and sugar-content analysis. We determined brix and pol from the juice and used them to estimate theoretical sugar yield (kg of sugar per ton of cane) (2). We tested the sugar yield means of the samples from areas adjacent to and away from skip areas for differences, using a one-tailed t-test for two sample means.

The rows of the respective plots were harvested during February 1976, again with a Massey-Ferguson 201 chopper harvester. Cane from each row was delivered by the harvester into a citrus tub held by a forklift. We weighed the tub by placing it between two platform scales and recorded the gross cane weight. We determined the trash content of a sample of about 130 kg of cane delivered by the harvester. Gross cane yields were calculated for total plots and for border and skip rows in each plot. We tested the means of the total plot yield of each skip treatment for differences, using Duncan's Multiple Range Test. The percentage of row length skipped in each plot and the percentage of difference between the yield of each skip plot and that of the respective check plot was calculated. We tested the means of the border- and skip-row yields for differences, using Duncan's Multiple Range Test. The percentages of difference between border- and skip-row yields and the yield from check rows were calculated and compared with percentages of row length skipped in skip rows.

Average stalk weights were calculated for border and skip rows. We tested treatment means for differences, using Duncan's Multiple Range Test. We predicted plot yields from stalk populations, using regression analysis to examine the effect of stalk population on yield.

RESULTS

The sugarcane in the experiment was unusually erect and uniform in height, had an excellent burn, and did not present any problem to harvest mechanically. The trash content of the cane was determined to be 7.7%. Net cane values can be determined by multiplying gross values by 0.923.

Total-plot yields of the 1-, 2-, and 3-m skip treatments were similar to the yield from the check treatment (Table 1). The 4- and 5-m skip treatments had lower yields than the other treatments. The percentages of difference in yield between the 4- and 5-m skip treatments and the check treatment were lower than the percentages of unplanted row length for these treatments. These data showed that yield compensation for the unplanted portions of row length was occurring within the treatments.

Table 1. Yields of treated plots, amount of total plot-row length skipped, and difference between yield and check treatments for five skip treatments and a check treatment.

Skip length (m)	Yield of treated plots[1] (t/ha)	Amount of total plot-row length skipped (%)	Difference between yields of check and skip treatments (%)
0 (check)	133.0 b	0	0.0
1	135.8 b	5	2.29
2	129.7 b	10	- 2.57
3	130.9 b	15	- 1.48
4	120.1 a	20	- 9.70
5	114.3 a	25	-14.08

[1] Column values not followed by a common letter differ at the 5% level according to Duncan's Multiple Range Test.

Yields of the border rows for all skip treatments were similar to the yield from the check rows (Table 2). Statistically, variations in border-row yields overshadowed a slight yield compensation indicated by differences between yields from border rows and those from check rows (Table 2). Measurements of internodal stalk diameters in the border rows showed that stalk diameters in areas adjacent to skips averaged 28.2 mm, and stalk diameters in areas away from skip areas averaged 27.5 mm, a difference of 0.7 mm. This larger stalk diameter in areas adjacent to skips corresponds to about a 5% greater stalk weight, assuming a uniform stalk height.

Table 2. Yields of border and skip rows, amount of skip-row length skipped, and differences between yields of border and skip rows and yield of check rows for five skip treatments and a check treatment.

Skip length (m)	Border row yield[1] (t/ha)	Difference between yields of check- and border-rows (%)	Skip row yield[1] (t/ha)	Amount of skip-row length skipped (%)	Difference between yields of check- and skip-rows (%)
0 (check)	137.2 a	---	128.8 c	0	---
1	139.5 a	1.76	132.1 c	10	3.06
2	142.6 a	3.85	116.8 b	20	- 9.11
3	146.1 a	6.65	115.8 b	30	- 9.87
4	143.8 a	4.90	96.3 a	40	-25.00
5	143.9 a	4.99	84.6 a	50	-34.39

[1] Column values not followed by a common letter differ at the 5% level according to Duncan's Multiple Range Test.

The yield from the 1-m skip rows was similar to that from the check-rows, but the other skip treatments had lower yields than the check rows (Table 2). The percentages of yield reduction were not as large as the percentages of unplanted skip-row length, indicating compensation in the skip rows. For instance, the yield of the 5-m skip rows was only 34.3% below the yield of the check rows, yet 50% of the 5-m skip-row length was not planted. A similar trend existed for the 2- through 4-m skip-row treatments.

The stalk populations of border rows (Table 3) were similar for all treatments, indicating no compensation from increased tillering. The stalk population of the 1-m skip rows was similar to that of the check rows. The stalk populations of the 2- and 3-m skip rows were similar but lower than the population of the check rows. The densities of skip rows for all skip treatments, based on planted row length, were found to be higher than the density of check rows. The number of skip-row stalks over the equivalent planted length of check row averaged about 11 additional stalks per skip row for all skip treatments, showing that population compensation occurred from increased tillering. Stalk numbers apparently increased at each end of the skip and were equal to the equivalent growth of about 1 m of row length.

Table 3. Stalk populations of border and skip rows, stalk densities of planted length of skip rows, and the number of stalks in skip rows over the equivalent planted length of check rows for five skip treatments and a check treatment.

Skip length (m)	Border-row populations[1] (1000 stalks/ha)	Skip-row populations[1] (1000 stalks/ha)	Skip-row[2] densities (stalks/m)	Number of stalks in skip rows over equivalent planted length of check row (stalks)
0 (check)	74.31 a	71.44 d	11.43	---
1	77.88 a	73.31 d	13.03**	14.4
2	75.06 a	62.81 c	12.56*	9.1
3	75.88 a	59.12 c	13.51**	14.6
4	77.88 a	47.12 b	12.57*	6.8
5	75.00 a	41.30 a	13.22**	9.0
			Avg.	10.8

[1] Column values not followed by a common letter differ at the 5% level according to Duncan's Multiple Range Test.

[2] Column values followed by * differ from the check row value at the 5% level, and the values followed by ** differ at the 1% level, according to a one-tailed t-test for two sample means.

Average stalk weights (Table 4) showed some differences between skip treatments. The border rows of the 5-m skip treatment had the highest stalk weight of the border rows and were the only border rows for which stalk weight differed from that of the check rows. The stalk weights of the 4- and 5-m skip-row treatments were significantly higher than that of the check treatment, indicating compensation by increased growth.

Table 4. Stalk weights for border and skip rows for five skip treatments and a check treatment.

Skip length (m)	Border-row stalk weights[1] (kg)	Skip-row stalk weights[1] (kg)
0 (check)	1.86 bc	1.81 b
1	1.80 c	1.81 b
2	1.90 bc	1.87 b
3	1.93 ab	1.97 ab
4	1.85 bc	2.05 a
5	2.04 a	2.05 a

[1] Column values not followed by a common letter differ at the 5% level according to Duncan's Multiple Range Test.

The relationship between yield and stalk population in individual plots is shown in Fig. 2. Increases in plot population provided only small increases in plot yield when the plot population reached 62,000 stalks per hectare. A quadratic regression of plot population versus yield gave a correlation coefficient of 0.87. The predictor equation showed that yields would be maximum beyond the data range observed.

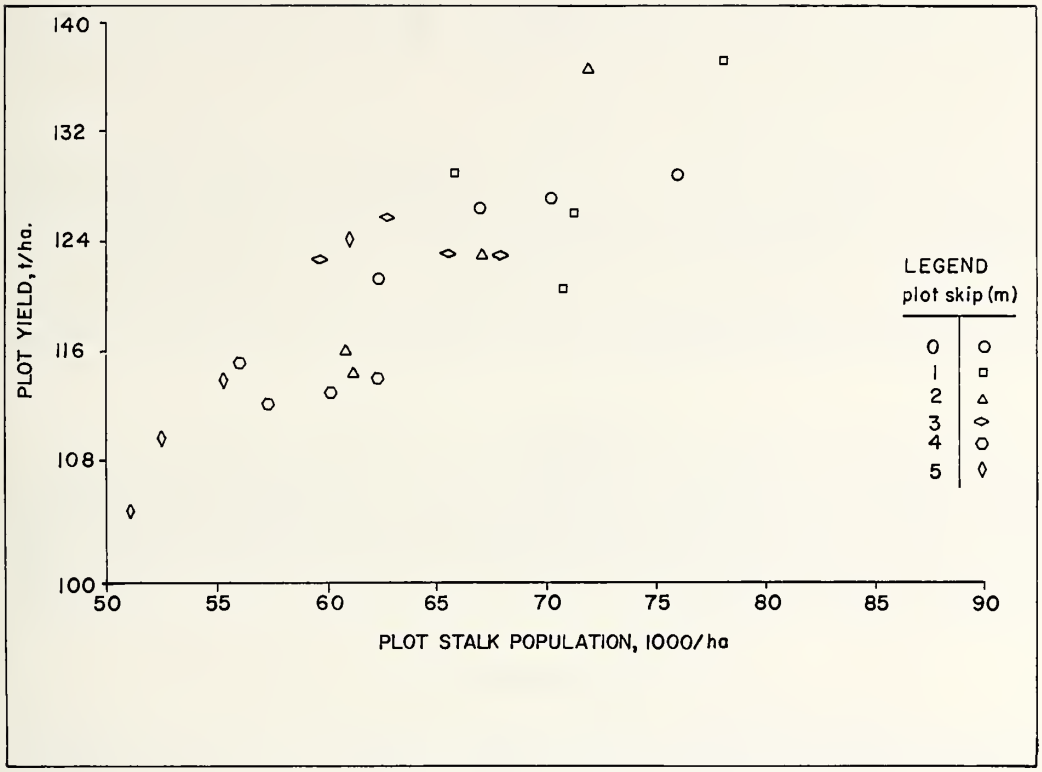

Fig. 2. Relationship between yield and stalk population in individual plots.

Stalks samples for sugar content from border-row areas adjacent to skips were found to have a lower sugar yield (133.6 kg/t) than samples taken in border-row areas away from skips (138.6 kg/t). We feel that the additional stalk growth in areas adjacent to the skips caused the lower sugar yield. Weetman and Hundertmark (5) noted that outside rows in experimental plots had a lower sugar yield than inside rows. They attributed the sugar yield difference to the increased stalk growth on the outside rows because of plant exposure to additional sunlight.

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PERFORMANCE AND DISTRIBUTION OF COMMERCIAL SUGARCANE VARIETIES IN TEXAS

S. A. Reeves, Jr.
Texas Agricultural Experiment Station
Weslaco, Texas

ABSTRACT

The use of superior sugarcane varieties is a highly important requirement for the survival and advancement of the Texas sugarcane industry. The introduction and/or the development of new varieties is thus a major feature of area research programs. The major variety presently grown in the Rio Grande Valley is NCo 310 followed in planted acreage by CP 52-68, CP 61-37, L 62-96, CP 44-101, CP 60-25 and CP 55-30. The varieties CP 56-59 and CP 65-357 were released to the growers in 1974 for production in the 1975-76 season. NCo 310 has been the leading variety in tonnage and sugar the past few years. The earliest maturing variety in Texas is L 62-96 followed by CP 65-357. The tonnage of the early maturing varieties has generally been lower than later maturing varieties due in part to early harvest.

INTRODUCTION

The sugarcane industry has been hampered by weather since the beginning of the first harvest season in 1973-74. There was a severe freeze on December 21, 1974, which stopped growth and damaged much of the cane. Much of the cane was not harvested that season. During the second sugarcane harvest season, there was a freeze on January 13 and 14. This also stopped growth and further sugar accumulation. All of the cane was harvested that year but the quality was very low at the end. The 1975-76 harvest season was the first without a major freeze. This is the first season that the performance of sugarcane varieties can be fully evaluated.

RESULTS AND DISCUSSION

The use of super sugarcane varieties is a highly important requirement for the survival and advancement of the Texas industry. The introduction and/or the development of new sugarcane varieties is a major feature of research programs.

Sugarcane variety research programs were conducted on a limited scale through 1964 and a more comprehensive approach was begun in 1968. In 1969 and 1970, a number of varieties were imported to Texas from breeding programs in Louisiana and Florida for evaluation under local conditions. Results from these early tests provided the basis for selection of varieties to be increased for commercial production in the first sugarcane harvest season in 1973 and 1974.

The seven sugarcane varieties selected for increase for the first production and harvest season were: NCo 310, CP 52-68, CP 61-37, L 62-96, CP 44-101, L 60-25, and CP 55-30. All of these varieties were in production the first year. Since this time, there have been two more varieties released for commercial sugar production. Two new varieties were released to the grower for seed cane increase in 1974. CP 56-59 and CP 65-357 were in limited production in the 1975-76 season.

The milling test on the variety CP 57-614 will be conducted in the 1976-77 harvest to determine if this variety will be released to growers. This variety is the earliest maturing variety tested in Texas.

The total acres of sugarcane planted in the Valley and the percentage of each variety are shown in Table 1. NCo 310 has been the leading variety in number of acres planted since the start of the Texas industry. The percentage of total acres has increased from 34.9 in 1973-74 to 45.2 in the 1975-76 season. This percentage is expected to increase further this coming year.

NCo 310 is classified as a later maturing sugarcane in Texas. The bulk of NCo 310 is harvested after December. Some of the most favorable attributes of NCo 310 are its tolerance to salinity and low temperature during the harvest season. These are two important factors to be considered in Texas. NCo 310 is an excellent ratooning cane and the yields remain high over several ratoons.

The second leading variety in Texas in acreage is CP 52-68. CP 52-68 has shown a slight decrease in its percentage over the three harvest seasons. CP 52-68 is classified as a mid-season variety in Texas. CP 52-68 performs best when harvested in December. When this variety is harvested before or after December, there is a trend for decrease in quality. CP 52-68 is susceptible to low temperatures and needs to be harvested before periods of highest incidence of freezing temperatures. CP 52-68 is very erect and undergoes burn-standing very well.

CP 61-37 is the third major variety in Texas. The percentage of this variety was increased for the 1975-76 harvest season. In the first two seasons, CP 61-37 exhibited a desirable characteristic of being an early variety. However, in the 1975-76 harvest season, this variety performed as a mid-season variety. Research data also has shown CP 61-37 to be more of a mid-season variety.

The varieties CP 44-101, CP 55-30, and L 60-25 are being phased out of production at the present time. The performance of L 62-96 has been very spotty. This variety is being kept and spread further because of its earliness. The yields of L 62-96 are not as high as the other varieties but the early sugar is essential for early harvest.

CP 56-59 and CP 65-357 are being spread now and will be in production in future years. The spread of CP 56-59 will be limited due to poor response in many areas. CP 65-357 has performed very well and is being spread as rapidly as possible.

The total acres of sugarcane for each season is shown at the bottom of Table 1. The acreage has grown each harvest season. The acreage in 1975-76 is the maximum that the one mill can handle so there will not be an increase in acreage for the coming season.

Only limited data are available concerning the number of ratoons that may be grown in the Valley due to the short history of the industry. The performance of several sugarcane varieties over several ratoon crops is shown in Table 2. This was a sugarcane test conducted at the Texas Agricultural Experiment Station at Weslaco. The data in this test show that there was essentially no decrease in the net tons of cane per acre over a seven-year period for NCo 310, CP 55-30, CP 44-101, and CP 52-68. There were variations with cycles but there was not a definite trend for decreasing or increasing yields. The data for L 60-25 did show a trend for decreasing yield with time. L 60-25 has been a very poor ratooning cane in the Valley. Long term data for other varieties are not available at the present time.

Table 1. Percentage of total acres of nine sugarcane varieties over three seasons.

	Harvest season		
Varieties	73-74	74-75	75-76
NCo 310	34.9	39.5	45.2
CP 52-68	21.3	19.8	16.4
CP 61-37	11.9	10.1	14.9
CP 44-101	14.2	13.6	9.3
L 62-96	10.4	11.3	10.0
CP 55-30	2.9	2.5	1.8
L 60-25	3.8	2.7	1.8
CP 56-59			0.22
CP 65-357			0.11
Others	0.6	0.5	0.6
Total acres	24,814.92	28,689.06	34,974.77

Source: W. R. Cowley Sugar Mill.

Table 2. Net tons cane per acre for nine sugarcane varieties over several ratoons.

Variety	Plant crop	1st R	2nd R	3rd R	4th R	5th R	6th R	Ave.
CP 55-30	55.3	84.6	78.9	63.5	49.5	67.9	59.6	63.9
NCo 310	70.6	62.1	57.2	51.0	55.3	69.0	63.4	59.2
CP 44-101	49.9	67.8	63.0	56.4	45.2	65.9	64.9	59.1
CP 52-68	62.1	81.5	58.2	47.9	47.1	74.5	59.4	57.4
L 60-25	50.0	55.9	46.0	36.8	25.8	48.1	42.1	39.8

Source: Texas Agricultural Experiment Station, Weslaco.

The tons sugar per acre for the same five varieties are shown in Table 3. The tons sugar per acre remained high after seven years even though there is a slight decline. Part of the variation in sugar per acre is due to different times of harvest each year. The yields in the 4 ratoons are lower for all varieties due in part to an early harvest that year. The varieties had a low sugar content and were not yet mature. With late maturing varieties, low sugar yields result from early harvest.

Table 3. Tons sugar per acre for nine sugarcane varieties over several ratoons.

Variety	Plant crop	1st R	2nd R	3rd R	4th R	5th R	6th R	Ave.
CP 55-30	6.2	9.4	8.7	7.2	5.6	8.2	5.9	7.1
CP 52-68	7.1	9.0	6.8	5.5	5.7	9.8	6.9	6.9
CP 44-101	5.5	7.5	7.6	6.3	5.4	8.3	6.4	6.8
NCo 310	8.1	6.3	4.3	5.5	6.4	7.7	5.4	6.2
L 60-25	5.9	6.9	5.4	4.1	3.0	6.1	5.0	4.7

Source: Texas Agricultural Experiment Station, Weslaco.

The commercial response of sugarcane varieties has shown the same trends as the research data. The tonnage and sugar per acre have been lower than research data but this is expected due to hand harvest and special care given research plots. The average yields for released sugarcane varieties milled this year are shown in Table 4. NCo 310 was the highest yielding sugarcane variety for the 1975-76 season. This was followed by CP 56-59 with 44.77 tons cane per acre but the acreage harvested was only around 600 acres. CP 52-68 and CP 61-37 were the second and third varieties in yield from large acreages. The early maturing varieties produced the lowest yield. This is due in most part to the short growing season for these varieties. The highest purities were obtained with NCo 310 and CP 52-68. This is due to the fact that the bulk of these varieties were harvested late when they were more mature. The early varieties were generally harvested before they reached full maturity.

Table 4. Average yield in tons cane per acre (TCA) and average normal purity for nine sugarcane varieties for the 1975-76 harvest season.

Variety	TCA	Normal purity
NCo 310	45.05	81.79
CP 56-59	44.77	78.51
CP 52-68	39.84	80.66
CP 61-37	37.50	77.79
CP 55-30	37.13	79.85
CP 44-101	36.46	78.57
CP 65-357	35.17	76.87
L 60-25	33.88	79.35
L 62-96	31.42	79.35

Source: W. R. Cowley Sugar Mill.

The ranges on commercial fields in yield of cane per acre and pol value during the 1975-76 harvest season are illustrated in Fig. 1 and 2, respectively, using data for the principal variety, NCo 310.

There were scattered fields harvested from mid-November to mid-December with the bulk of the variety harvested after this time. The yields of cane were generally below the seasonal mean until late December. The maximum yields were obtained in February and March. There was a decline in yield during April.

The pol values made a sharp rise in the middle of January. The pol value then remained above the seasonal average until a gradual decline began in March followed by a rapid decrease in April. The maximum yields and pol values were achieved at approximately the same time. The bulk of NCo 310 was harvested during this period. There does not appear to be any relation between the plant cycles and yield or quality. The data tend to show that there is no apparent difference between the plant crop and the ratoon crops in yields or pol values.

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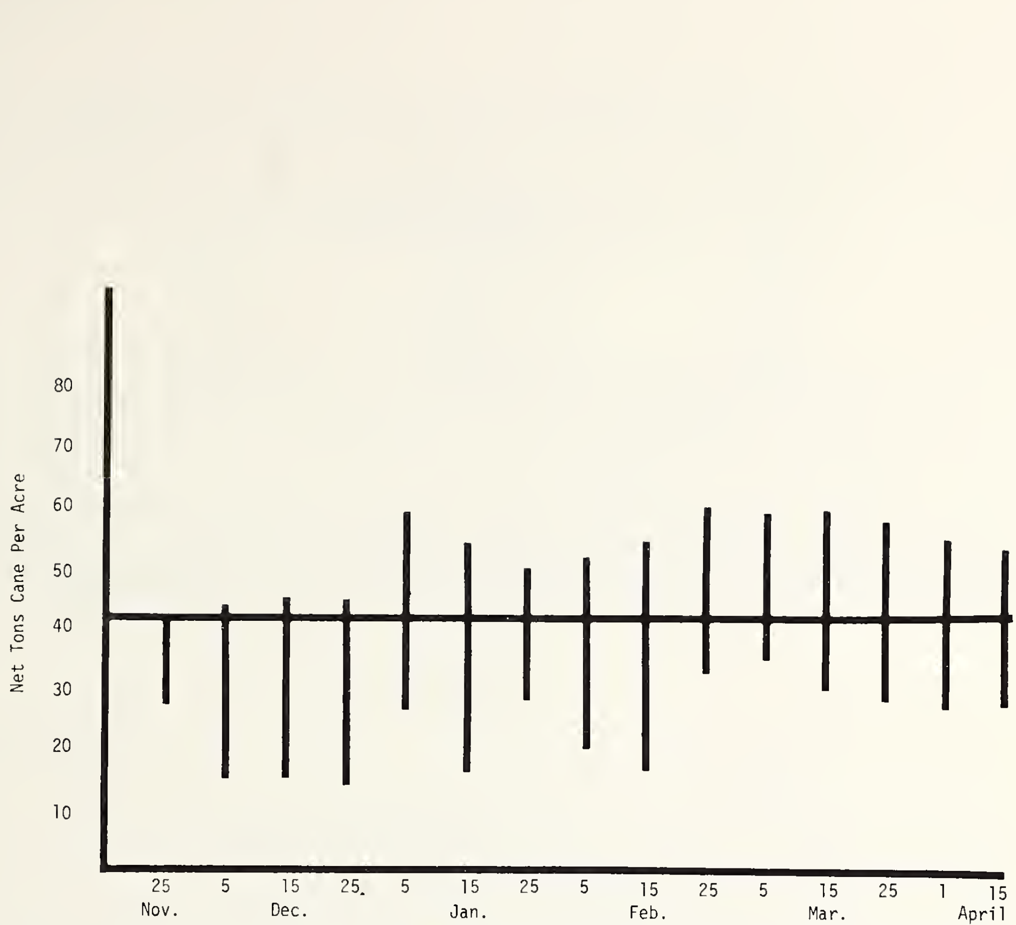

Figure 1. The range in net tons of cane per acre about the seasonal average for NCo 310.

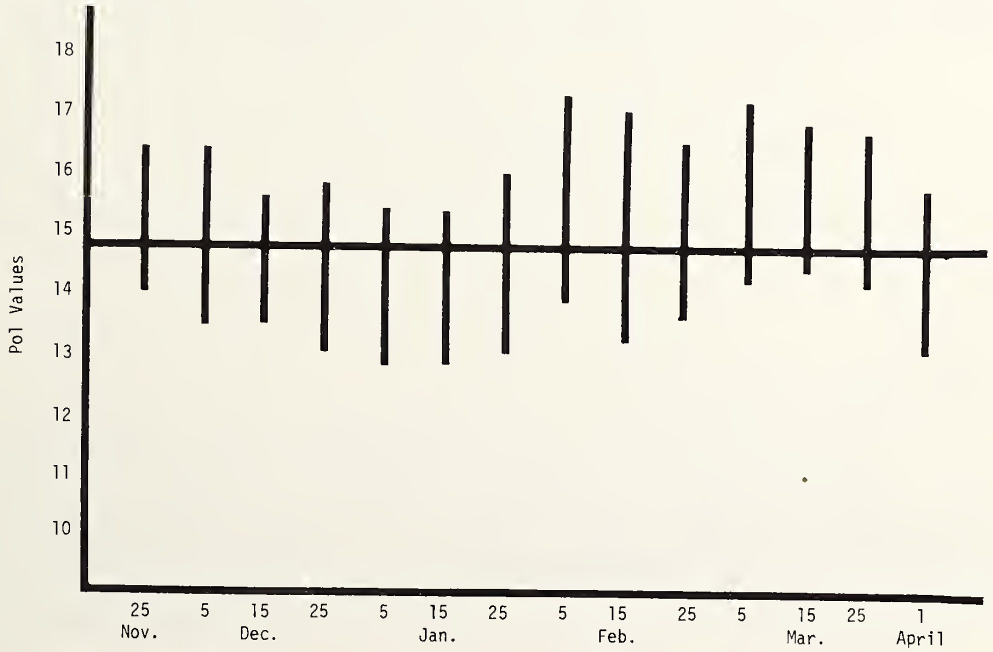

Figure 2. The range in pol values about the seasonal average for NCo 310.

EFFECT OF SUBSOILING ON SUGARCANE PRODUCTION IN LOUISIANA[1/]

Ray Ricaud
Agronomy Department
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana 70803

ABSTRACT

Soil compaction is becoming a serious problem on sandy soils in the Louisiana sugarcane area. This is due mainly to the use of heavier field equipment under wet conditions and to the lack of effective subsoiling. Several experiments were conducted to determine the effect of subsoiling with a regular subsoiler and a vertical mulcher subsoiler on soil compaction and the yield of sugarcane. The subsoilers were operated under each row to a depth of 24 in. prior to planting in the fall. Subsoiling with a regular subsoiler increased cane yield an average of 5.0 tons per acre or 19.3%. Subsoiling with a vertical mulcher subsoiler increased cane yield an average of 9.8 tons per acre or 40.2%. This was due to an increase of 19.4% in stalk number and 24.3% in individual stalk weight. The mulcher subsoiler was considerably more effective than the regular subsoiler in increasing cane yield. The increases were larger in plant cane than in stubble cane. The incorporation of bagasse in the subsoil with the vertical mulcher subsoiler did not increase cane yield. Although large increases in yield were obtained in a second cycle of cane after subsoiling, it was beneficial to subsoil prior to planting each cane crop.

INTRODUCTION

Soil compaction is becoming a serious problem in sugarcane production in Louisiana. This is due to the increase in the use of heavier field equipment and to the lack of effective deep tillage or subsoiling to reduce soil compaction.

The amount of compaction in the soil may vary among soil types depending mainly on their clay and organic matter content. Most soils can be compacted with heavy equipment traffic under certain moisture conditions. However, the residual compaction is relatively low in soils with a high clay content due to the shrinking and cracking of the soil during dry periods.

Sandy soils with a low clay and organic matter content compact to form a dense layer or hardpan in the subsoil. This hardpan is usually from 6 to 8 in. in thickness and occurs immediately below the plowed layer in the soil. It can form by traffic from normal tillage and restrict root development. According to Meredith and Patrick (2) soil compaction increases the bulk density and decreases the porosity, water infiltration, and root penetration in the soil.

The effect of soil compaction on sugarcane yield may depend on the variety of cane and the amount and distribution of rainfall during the growing season. The yield from vigorous varieties with a strong root system is less likely to be adversely affected by soil compaction. However, a poor root penetration in the subsoil can reduce the water uptake and yield of most cane varieties during dry periods in the summer.

Saveson, et al. (4) found that deep tillage can increase cane yield on fine sandy loam and silty clay loam soils, especially in years of poor rainfall distribution. Patrick, et al. (3) reported that deep tillage can increase root development and yield on soils with traffic pans in years of low rainfall. Heilman, et al. (1) obtained significant increases in cotton yield from trenching 5 in. wide to a depth of 40 in. under each row prior to planting in the low rainfall area of the Rio Grande Valley.

The purpose of this paper is to discuss the results from several experiments on subsoiling in the sugarcane area of Louisiana.

EXPERIMENTAL PROCEDURES

Seven experiments were conducted to determine the effects of subsoiling on the yield and certain growth characteristics of sugarcane. The experiments were on locations, soil types, and with cane varieties shown in Table 1.

The experiments were located on soil types which appeared to have a compaction problem. Experiments 1, 2, 3, and 4 were with plant and stubble cane on Commerce silt loam soil at different locations on Allendale Plantation in West Baton Rouge Parish. Experiment 5 was with plant and stubble cane on Commerce silt loam soil at Alma Plantation in Pointe Coupee Parish. Experiment 6 was with plant cane on Jeanerette silt loam soil at M. A. Patout Plantation in Iberia Parish. Experiments 1 through 6 were conducted during the first cycle of cane after subsoiling. Experiment 7 was conducted on Commerce silt loam soil at Allendale to determine the residual effect of subsoiling in a second cycle of cane.

[1/] This research is supported in part by grant funds from the American Sugar Cane League and by sugarcane growers.

Table 1. The location, soil type, cane variety, and year of each experiment.

Experiment no.	Location[1]	Soil type	Cane variety	Year conducted
1	Allendale	Commerce sil	CP 48-103	1968-69
2	Allendale	Commerce sil	L 60-25	1969-70
3	Allendale	Commerce sil	L 60-25	1970-72
4	Allendale	Commerce sil	L 62-96	1972-75
5	Alma	Commerce sil	CP 48-103	1972-74
6	Patout	Jeanerette sil	NCo 310	1974
7	Allendale	Commerce sil	L 60-25	1974-75

[1]/Sugarcane plantations.

The subsoilers tested were a regular subsoiler and a vertical mulcher subsoiler. The regular subsoiler consisted of a typical subsoiling shank. It opened a narrow furrow approximately 1 1/2 in. in width. The vertical mulcher subsoiler was constructed to open a furrow 11 in. wide at the top and 5 in. wide at the bottom of the subsoiling furrow. It was originally designed with a large hopper to incorporate plant residue into the subsoil. The incorporation of bagasse was found to be very difficult and not beneficial for increasing the effectiveness of subsoiling. Therefore, the original model was redesigned and built without the capability for incorporation but retained its original name.

The regular subsoiler was tested in Experiments 1 and 2 and the vertical mulcher subsoiler was tested in all the experiments. The incorporation of bagasse was tested in Experiment 1 by filling the subsoiling furrow with bagasse.

Experiment 7 was conducted during a second cycle of cane following the first cycle in Experiment 3. The rows were maintained in their original position during the fallow year between cycles to keep the subsoiling furrow under each row. One-half of the subsoiled plots was subsoiled again with a vertical mulcher subsoiler prior to planting the second cycle of cane.

The regular and vertical mulcher subsoilers were operated under each row at a depth of 24 in. prior to planting cane on plots in a normal manner after the rows were rebuilt and allowed to settle by rainfall. The plots were three rows wide and from 500 to 800 ft long. The subsoiling treatments, including a check without subsoiling, were replicated three times in a randomized block design in each experiment.

The cane yield and percent brix and sucrose in the cane juice were measured on each plot at a normal harvest time. The sugar yields were calculated in accordance with the data published annually by the USDA on sugar commercially recoverable from sugarcane (5).

The stalk population and the individual stalk weight of the millable cane were measured at harvest time in some of the experiments. The amount and distribution of cane roots were observed with and without subsoiling. A soil penetrometer equipped with a probe 1/2 in. in diameter was used to measure soil compaction.

RESULTS AND DISCUSSION

The data obtained in Experiments 1 through 4 on Commerce silt loam soil at Allendale Plantation are reported in Table 2. The increases in cane and sugar yields with the vertical mulcher subsoiler over the check without subsoiling were relatively large with plant and stubble cane in each experiment. In the two experiments or four crop years in which the regular subsoiler was tested, it produced a significant increase in yield only with plant cane in one year. The vertical mulcher subsoiler produced a significant increase in yield over the regular subsoiler in three out of the four crop years. The incorporation of bagasse into the subsoil with the vertical mulcher subsoiler did not increase yield over subsoiling alone.

The data obtained in Experiment 5 on Commerce soil at Alma Plantation and in Experiment 6 on a Jeanerette soil at M. A. Patout Plantation are presented in Table 3. The increases in the cane and sugar yields from subsoiling with the vertical mulcher subsoiler were significant at these two locations. However, the increases were smaller on the Jeanerette soil than on the Commerce soil.

A summary of the increases in cane yield, stalk population and weight from subsoiling in the six experiments with first cycle cane is presented in Table 4. The regular subsoiler increased cane yields an average of 5.0 tons per acre or 19.3% in two experiments. The increases in cane yields with the vertical mulcher subsoiler in all the experiments or 14 crop years ranged from 219 to 18.1 tons per acre with an average of 9.8 tons or 40.2%. The increases were generally largest with plant cane and decreased with each successive stubble crop.

Table 2. Effect of subsoiling on the yield of sugarcane in four experiments on Commerce silt loam soil at Allendale Plantation.

Subsoiling treatment	Cane yield (tons/a)	Stalk		Normal sucrose %	Sugar yield (lb/a)
		Number (1000/a)	Weight (lb/stalk)		
Exp. 1, plant cane, CP 48-103, 1968					
Check	23.8	23.8	2.00	16.1	5610
Regular	29.2	26.9	2.17	15.6	6645
V. mulcher	41.9	27.9	3.00	14.7	8862
V. mulcher + bag.1/	37.9	28.1	2.70	14.7	8051
LSD .05	6.7				1484
Exp. 1, first stubble, CP 48-103, 1969					
Check	22.5	28.6	1.57	13.5	4298
Regular	26.8	32.1	1.67	14.4	5516
V. mulcher	38.9	32.8	2.37	15.7	8916
LSD .05	6.3				1328
Exp. 2, plant cane, L 60-25, 1969					
Check	35.1	35.1	2.00	13.3	7188
Regular	39.5	33.3	2.37	14.0	8738
V. mulcher	48.1	36.0	2.67	13.8	10,438
LSD .05	2.9				553
Exp. 2, first stubble, L 60-25, 1970					
Check	26.0	31.0	1.68	13.6	5057
Regular	32.0	33.5	1.91	14.7	6771
V. mulcher	37.7	35.7	2.11	13.8	7372
LSD .05	6.8				1359
Exp. 3, plant cane, L 60-25, 1970					
Check	27.3	29.8	1.83	15.3	6083
V. mulcher	39.4	36.1	2.18	14.8	8422
LSD .05	3.8				815
Exp. 3, first stubble, L 60-25, 1971					
Check	24.0	-	-	13.1	4477
V. mulcher	30.4	-	-	13.4	5784
LSD .05	4.2	-	-		792
Exp. 3, second stubble, L 60-25, 1971					
Check	23.4	32.5	1.44	14.3	4788
V. mulcher	28.3	40.1	1.41	13.9	5633
LSD .05	4.3				869
Exp. 4, plant cane, L 62-96, 1972					
Check	24.5	22.1	2.22	14.2	4971
V. mulcher	37.5	28.6	2.62	13.1	6930
LSD .05	3.2				676
Exp. 4, first stubble, L 62-96, 1973					
Check	22.8	22.1	2.06	12.9	4135
V. mucler	33.1	27.1	2.44	13.0	6029
LSD .05	5.2				934
Exp. 4, second stubble, L 62-96, 1974					
Check	20.9	24.6	1.70	13.9	4118
V. mulcher	26.7	29.5	1.81	14.3	5474
LSD .05	4.0				804

(Continued)

Table 2. Continued

Subsoiling treatment	Cane yield (tons/a)	Stalk		Normal sucrose %	Sugar yield (lb/a)
		Number (1000/a)	Weight (lb/stalk)		
		Exp. 4, third stubble, L 62-96, 1975			
Check	20.4	20.3	2.01	14.1	4116
V. mulcher	29.9	26.7	2.24	13.9	5905
LSD .05	6.2				1243

1/Bagasse incorporated in subsoil with a vertical mulcher subsoiler.

Table 3. Effect of subsoiling on the yield of sugarcane in Experiment 5 on Commerce soil at Alma Plantation and in Experiment 6 on Jeanerette soil at M. A. Patout Plantation.

Subsoiling treatment	Cane yield (tons/a)	Normal juice			Sugar yield (lb/a)
		Brix	Sucrose	Purity	
		-----------------%--------------------			
		Exp. 5, plant cane, CP 48-103, 1972			
Check	24.4	16.9	12.7	75.5	4343
V. mulcher	32.0	16.6	12.4	75.0	5529
LSD .05	2.9				486
		Exp. 5, second stubble, CP 48-103, 1974			
Check	20.2	18.5	14.9	80.5	4340
V. mulcher	24.3	18.4	15.2	82.2	5329
LSD .05	2.4				523
		Exp. 6, plant cane, NCo 310, 1974			
Check	24.2	16.8	13.0	77.5	4410
V. mulcher	27.1	17.6	14.1	80.4	5466
RSD .05	2.2				423

Table 4. Increases in cane yield, stalk population and individual stalk weight from subsoiling with a regular subsoiler and a vertical mulcher subsoiler.

Experiment no.	Age of cane	Increases from subsoiling[1]			
		Cane yield		Stalk no.	Stalk wt.
		(tons/a)	%	%	%
		Regular subsoiler			
1	Plant cane	5.4	22.7	13.0	8.5
1	First stubble	4.3	19.1	12.2	6.4
2	Plant cane	4.4	12.5	- 5.1	18.5
2	First stubble	6.0	23.1	8.1	13.7
Mean		5.0	19.3	7.1	11.8
		Vertical mulcher subsoiler			
1	Plant cane	18.1	76.1	17.2	50.0
1	First stubble	16.4	72.9	14.7	51.0
2	Plant cane	13.0	37.0	2.6	33.5
2	First stubble	11.7	45.0	15.2	25.6
3	Plant cane	12.1	44.3	21.1	19.1
3	First stubble	6.4	26.7	-	-
3	Second stubble	4.9	20.9	23.4	- 2.1
4	Plant cane	13.0	53.1	29.4	18.0
4	First stubble	10.3	45.2	22.6	18.4
4	Second stubble	5.8	27.8	19.9	6.5
4	Third stubble	9.5	46.6	31.5	11.4
5	Plant cane	7.6	31.1	-	-
5	Second stubble	4.1	20.3	-	-
6	Plant cane	2.9	12.0	-	-
Mean		9.8	40.2	19.4	24.3

1/Increases over the check without subsoiling.

The average increases in stalk number and weight were 7.1 and 11.8%, respectively, with the regular subsoiler and 19.4 and 24.3%, respectively, with the vertical mulcher subsoiler.

The vertical mulcher subsoiler was considerably more effective than the regular subsoiler in increasing the cane yield, millable stalk population, and individual stalk weight. The effect of subsoiling with both subsoilers was more pronounced in the stalk weight or cane height than in the stalk population.

The results from subsoiling with a vertical mulcher subsoiler during a second cycle of cane in Experiment 7 are presented in Table 5. The yield increases with plant cane were 6.6 tons per acre on plots subsoiled only prior to the first cycle and 9.9 tons per acre on plots subsoiled prior to the first and second cycles. The yield increases with first stubble cane were 9.0 tons per acre on plots subsoiled prior to the first cycle and 12.5 tons per acre on plots subsoiled prior to the first and second cycles.

Table 5. Effect of subsoiling on the yield of sugarcane in a second cycle of cane in Experiment 7 on Commerce soil at Allendale Plantation[1].

Subsoiling treatment	Cane yield (tons/a)	Stalk Number (1000/a)	Stalk Weight (lb/stalk)	Normal sucrose %	Sugar yield (lb/a)
		Subsoiled first cycle, plant cane, 1974			
Check	20.5	26.6	1.54	13.6	3954
V. mulcher	27.1	30.1	1.80	13.2	5061
LSD .05	3.4				655
		Subsoiled first and second cycles, plant cane, 1974			
Check	19.2	25.3	1.52	13.8	3784
V. mulcher	29.1	31.3	1.86	14.0	5793
LSD .05	3.4				655
		Subsoiled first cycle, first stubble, 1975			
Check	17.4	28.5	1.22	14.5	3667
V. mulcher	26.4	35.7	1.48	14.1	5291
LSD .05	3.0				615
		Subsoiled first and second cycles, first stubble, 1975			
Check	16.5	27.3	1.21	14.1	3332
V. mulcher	29.0	36.2	1.60	14.3	5908
LSD .05	3.0				615

[1] Plant and first stubble yields with variety L 60-25 during a second cycle of cane on plots subsoiled with a vertical mulcher subsoiler prior to the first cycle only and prior to the first and second cycles.

The results indicated that although large increases in yield were obtained in the second cycle after subsoiling, it was beneficial to subsoil prior to planting each cycle of cane. Also, it was difficult to maintain rows in their original position in order to keep subsoiling furrow under each row during the fallow year between cane cycles.

The effect of subsoiling with a vertical mulcher subsoiler on soil compaction is shown in Table 6. The data were obtained during the spring of the first stubble year in Experiment 3 approximately 18 months after subsoiling.

Table 6. Effect of subsoiling with a vertical mulcher subsoiler on soil compaction in the first stubble year of Experiment 3 on Commerce soil at Allendale Plantation.

Distance from center of row[1] (inches)	Penetrometer values[2]		
	In hardpan		Below hardpan
	Not subsoiled	Subsoiled	
	(pounds)		
0	170	30	20
6	180	45	25
12	180	60	20
18	160	70	20
24	135	85	20
30	130	110	20
36	130	120	25

[1] Penetrometer measurements were made six inches apart from the center of cane rows to the middles approximately 18 months after subsoiling.

[2] Pounds required to penetrate the soil with a probe one-half inch in diameter.

The amount of compaction, as indicated by soil penetrometer values, was very high in the hardpan without subsoiling. The compaction in the hardpan was higher under the row than under the middles or inter-row. This was probably due to the deepening of the middles during cultivation. The soil compaction was low under the row after subsoiling. The compaction was lowest in the area of the subsoiling furrow and increased progressively towards the middles. This indicates that the horizontal force caused by the wide subsoiler probably fractured the hardpan on both sides of the subsoiling furrow. However, the compaction was not reduced appreciably in the middles, where it was needed for good traction of equipment during harvest time. The penetrometer values were very small below the hardpan indicating no compaction problems deeper in the root zone.

The penetration of cane roots through the hardpan on the check plots was very poor. It was estimated by observation that approximately 5% of the roots were feeding below the hardpan without subsoiling. The root system was considerably deeper where the hardpan was eliminated by subsoiling. The cane leaves showed less symptoms of moisture stress with than without subsoiling during dry periods in the summer time.

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EXCESS WATER DECREASES CANE AND SUGAR YIELDS[1/]

Cade E. Carter
USDA-ARS
Baton Rouge, Louisiana

ABSTRACT

Yields of sugarcane under excess water--rainfall in excess of the amounts needed for evaporation from the soil, transpiration by plants, and storage in the soil--from Baton Rouge, Donaldsonville, Houma, and Franklin, Louisiana, were compared with average cane and sugar yields in West Baton Rouge, Assumption, Terrebone, and St. Mary Parishes, respectively, during 1963 through 1973. Yield decreases ranged from 0.21 to 0.95 ton per acre for cane and from 51 to 186 lb per acre for sugar for each 1-inch increase in excess water. Excess water amounts used in this study were received during various combinations of months between December and April, and yields were for the next crop. Excess water often exceeded 20 inches during the 5-month period, December through April. Excess water for groups of months that included February and March (FM) such as JFM, FMA, DJFM, or FM, tended to affect yields more than did excess water for groups of months that excluded FM, indicating that excess water during these two months may be critical. Usually, sugarcane begins root and shoot growth in late February and early March and may be susceptible to damage by excess water during this time. Results of this study emphasize the need for improved management practices, such as drainage, that will remove excess water from the soil and reduce its damaging effects to cane and sugar yields in Louisiana.

INTRODUCTION

Sugarcane is a tropical plant that requires large quantities of water and sunshine, high temperatures, and a relatively long frost-free growing period. Although Louisiana's climate is not tropical, sugarcane was introduced into the state in 1751 and later became a major crop in the south-central parishes. Climatic and soil conditions in this area are usually favorable for growing cane during the frost-free period of March through mid-November. Although cane doesn't reach full maturity during this relatively short period, it grows reasonably well most years and yields enough sugar to make it sufficiently profitable that many farmers continue producing it.

Yields do fluctuate considerably from year to year (Fig. 1). The most frequently mentioned reason for these yield fluctuations is adverse climatic conditions, such as low temperatures in the spring, too much water, or not enough water. McDonald (5) reported in 1926 that high rainfall from July through January resulted in low yield from the next cane crop. Later, after cane planting dates were changed from January-March to August-October and many of the production practices that affect cane yield, such as weed and insect control, fertility, varieties, and surface drainage had been improved, another study relating climate and yields was reported by Lal and Patrick (4). They showed that excess moisture, particularly in March, resulted in low cane yields from the following crop. Sugarcane yields for Louisiana peaked in 1963, when the state average was 29.0 tons/acre. Since that time yields have declined. The reason for this decline is unknown, but weather conditions may be partially responsible. A small plot experiment at Baton Rouge showed that high water tables during the dormant season, December through March, reduced cane yields from the next crop (3). The small plot experiments were not designed, however, to determine the exact time when this damage to the cane occurred.

The purpose of this study was to determine the influence of one aspect of climate--excess water--on cane and sugar yields from 1963 to 1973, a period when yields in Louisiana decreased from 29.0 tons/acre in 1963 to 20.6 tons/acre in 1973--a production level similar to that 30 years ago.

[1/] Contribution of Agricultural Research Service, USDA, in cooperation with the Louisiana Agricultural Experiment Station, Baton Rouge, La.

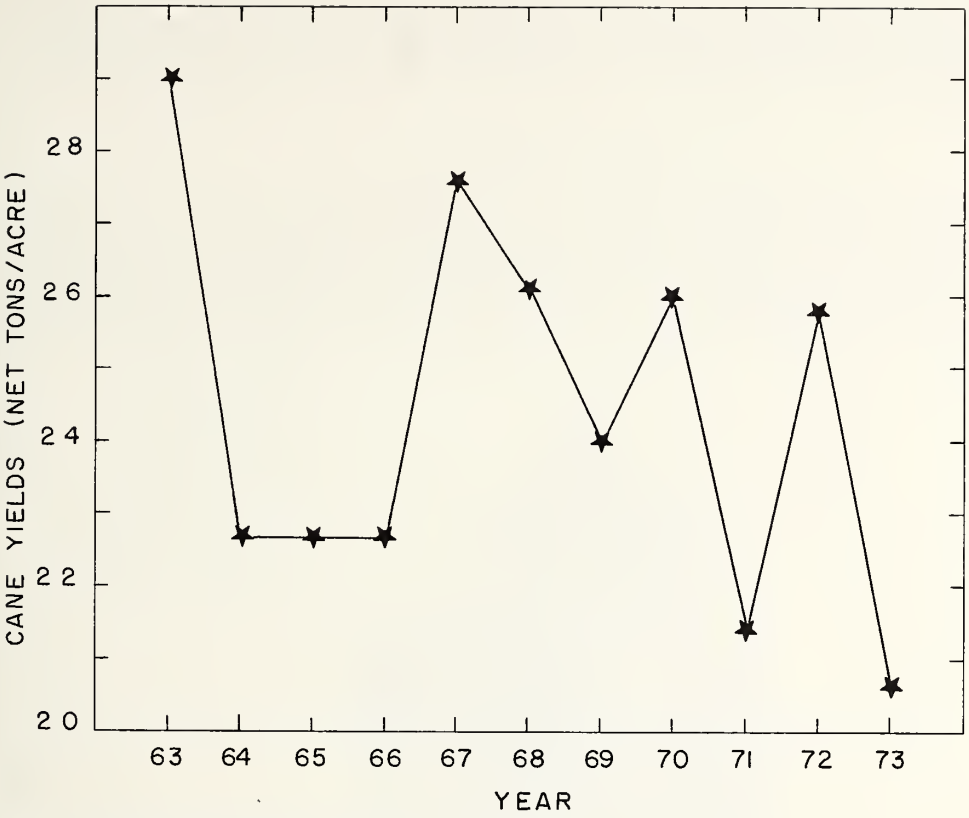

Fig. 1. Louisiana annual cane yields. 1963-1973.

PROCEDURE

Excess water is defined here as the amount remaining after evaporation, transpiration, and soil storage requirements have been met. This excess water may pond on the surface of the soil and possibly cause runoff through surface drainage systems, or may accumulate in the soil profile and cause the water table to rise.

The amount of water needed to meet the requirements for evaporation from the soil and transpiration by plants (evapotranspiration) was estimated using Thornthwaite's Water Balance Method (7, 8). This estimated need was then compared with water sources--monthly rainfall and water stored in the soil--to determine if the sources were sufficient to meet the estimated need. If more water was available than needed, this extra water was classified as water excess. If water was insufficient to meet the estimated need, the difference was classified as water deficit. Equations and tables for determining the estimated water need are given by Thornthwaite (8). Data on average monthly temperatures, monthly rainfall, latitude of the location, and water storage capacity of the soil were required in making these estimates. Temperature and rainfall data were obtained from the U. S. Department of Commerce (9). The water storage capacity of the soil's total root environment was estimated as 6 inches.

Monthly water balances were determined for four different locations--Baton Rouge, Donaldsonville, Houma, and Franklin. The water excesses and deficits for each of these locations for 1963 through 1973 were compared to the annual average sugarcane and sugar yields for the parishes of West Baton Rouge, Assumption, Terrebonne, and St. Mary, respectively. Yield data were obtained from the Sugar Bulletin (6).

Cane and sugar yields during 1963-1973 were not significantly correlated with water deficits. There was evidence, however, of good correlation between water excess and cane and sugar yields. To evaluate this more fully, excess water during the months of December (D), January (J), February (F), March (M), and April (A) (months that account for most of the excess) was compared with cane and sugar yields from the next crop individually and in the following combinations: DJ, DJF, DJFM, DJFMA, JF, JFM, JFMA, FM, FMA, and MA. The linear equation that provided the best fit for the data points was evaluated for each set of data using the method of least squares. A test was made to determine if the slope of the line (regression coefficient) in eqch equation was significantly different from zero and a coefficient of determination, r^2, was calculated.

The time span used in this study was from 1963 through 1973, with 1971 data excluded because Hurricane Carmen caused considerable damage to the cane crop that year. Care must be exercised in selecting a time span for a study such as the one reported here. If the span is too wide (20 years, for example) the weather-yield relationship may be obscured because of rapidly changing varieties and cultural practices.

RESULTS AND DISCUSSION

The average monthly potential evapotranspiration (ET) for Baton Rouge is shown in Fig. 2. The potential ET for the other three locations in this study was similar in pattern but slightly higher in amount. Monthly water needs in the Louisiana cane-producing area are seldom balanced with monthly supply. Large water excesses usually occur in the winter months when evapotranspiration is low and rainfall is high, whereas water deficits occur in the summer when evapotranspiration is often higher than rainfall. Fig. 3 shows water excesses and deficits at Baton Rouge in 1969, when water deficits were unusually high.

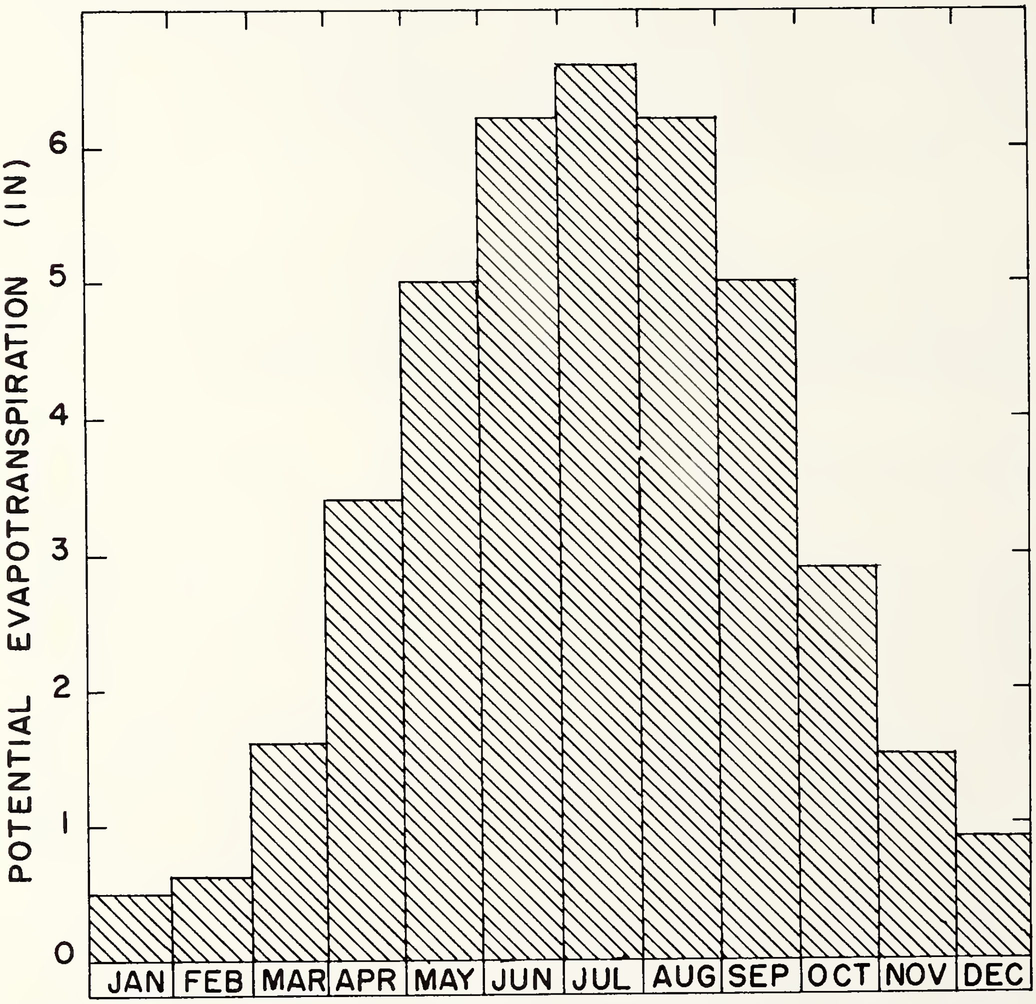

Fig. 2. Average monthly potential evapotranspiration. Baton Rouge, Louisiana. 1963-1973.

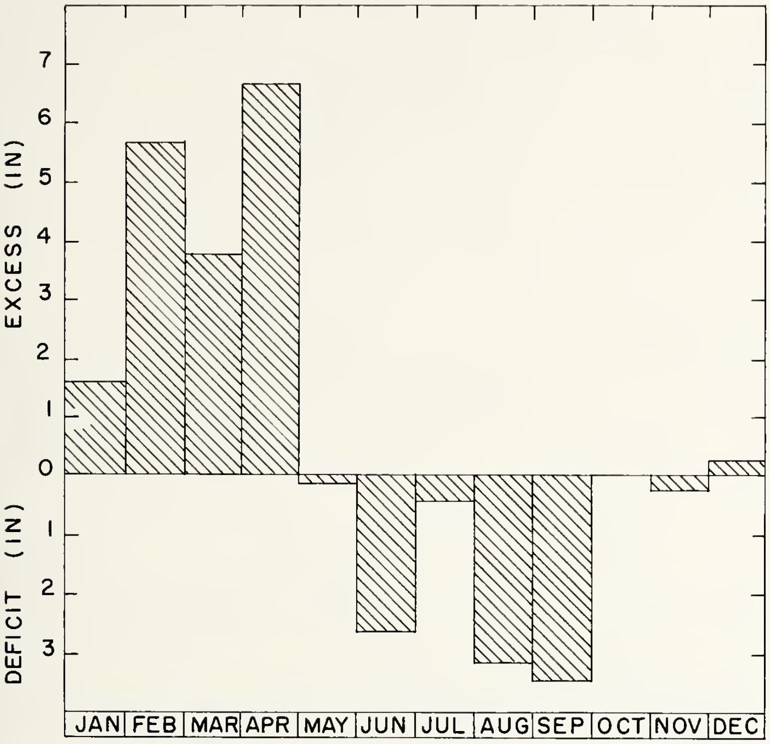

Fig. 3. Monthly water excess and deficits. Baton Rouge, Louisiana. 1969.

Excess water during the winter and spring months was associated with lower cane and sugar yields from the subsequent crop. A negative, linear relationship between water excess and yield was very pronounced for each of the four parishes, with coefficients of determination (r^2) reaching 72%. Coefficient of determination is the proportion of the total sum of squares accounted for by the regression models, which, in this case, is the regression of cane and sugar yields on water excess. The three combinations of months that gave the highest coefficients of determination for excess water and cane and sugar yields for West Baton Rouge, Assumption, Terrebonne, and St. Mary Parishes are shown in Fig. 4, 5, 6, and 7, respectively. Months when water excess was significantly (5% level) correlated with cane yields and sugar yields in these parishes are shown in Tables 1 and 2, respectively, along with the coefficients of determination and regression coefficients.

In West Baton Rouge Parish, 65 and 63% of the variation in cane and sugar yields, respectively, were associated with water excess during FM (Fig. 4). The slope of the line best fitting the cane yield and water excess data (regression coefficient) was -0.54, indicating a decrease of 0.54 ton of cane per acre for each inch of excess water. The regression coefficient for sugar yield and excess water was -134, indicating a decrease of 134 lb of sugar per acre for each inch of excess water. Water excess during DJFM and FMA was associated with almost 60% of the variation in cane yields.

In Assumption Parish the highest coefficients of determination for water excess and cane yields and water excess and sugar yields were 72 and 71%, respectively (Fig. 5 and Tables 1 and 2). These relatively high values were for water excess during FMA for cane yields and during FM for sugar yields. The regression coefficient indicated that cane yields decreased 0.57 ton per acre and sugar yields decreased 186 lb per acre for each inch of excess water during FMA and FM, respectively.

In Terrebonne Parish, 63% of the variation in cane yields and 55% of the variation in sugar yields were associated with excess water during JFMA (Fig. 6 and Tables 1 and 2). Cane yields decreased 0.33 ton per acre and sugar yields decreased 73.2 lb per acre for each inch of excess water during JFMA.

In St. Mary Parish, 67% of the variation in cane yields was due to water excess during FMA and 59% of the variation in sugar yields was due to water excess during JFMA and DJFMA (Fig. 7 and Tables 1 and 2). The regression coefficient indicated that cane yields decreased 0.41 ton per acre and sugar yields 82 lb per acre for each 1-inch increase of excess water.

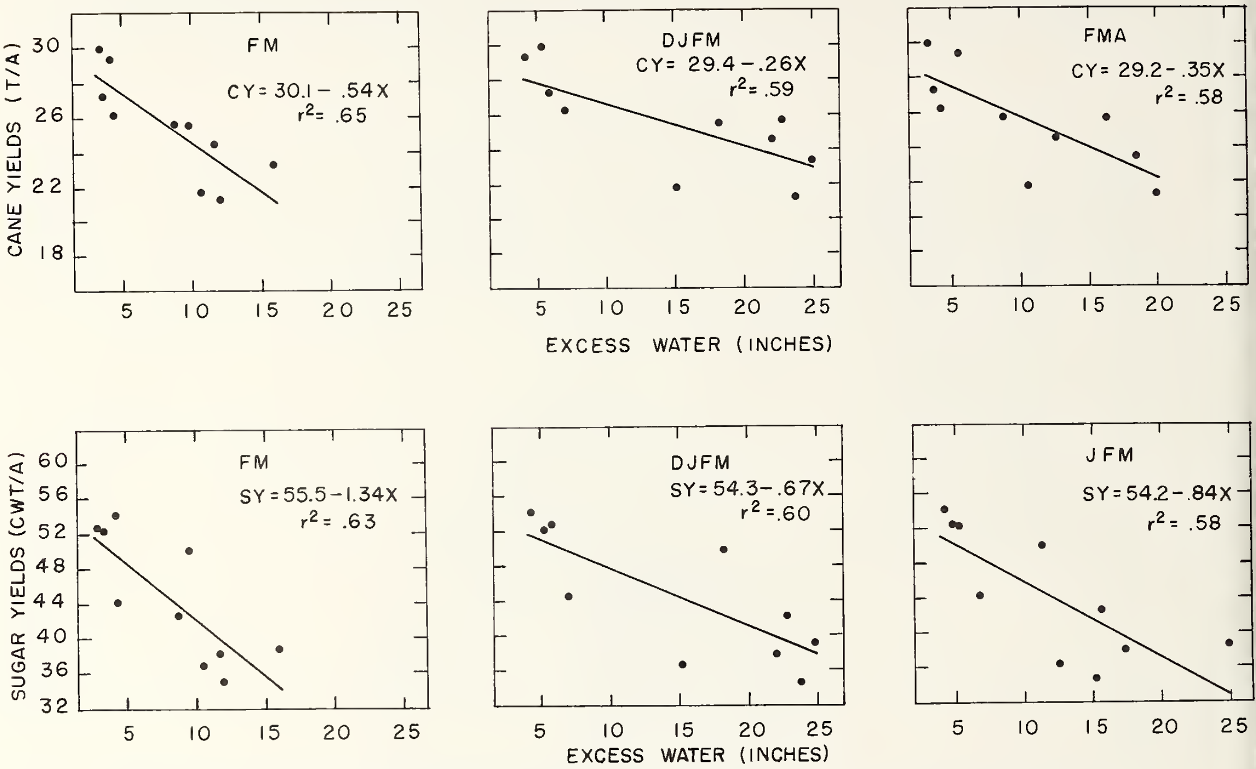

Fig. 4. Relationship between average parish cane and sugar yields and excess water during various months. West Baton Rouge Parish, Louisiana. 1963-1973.

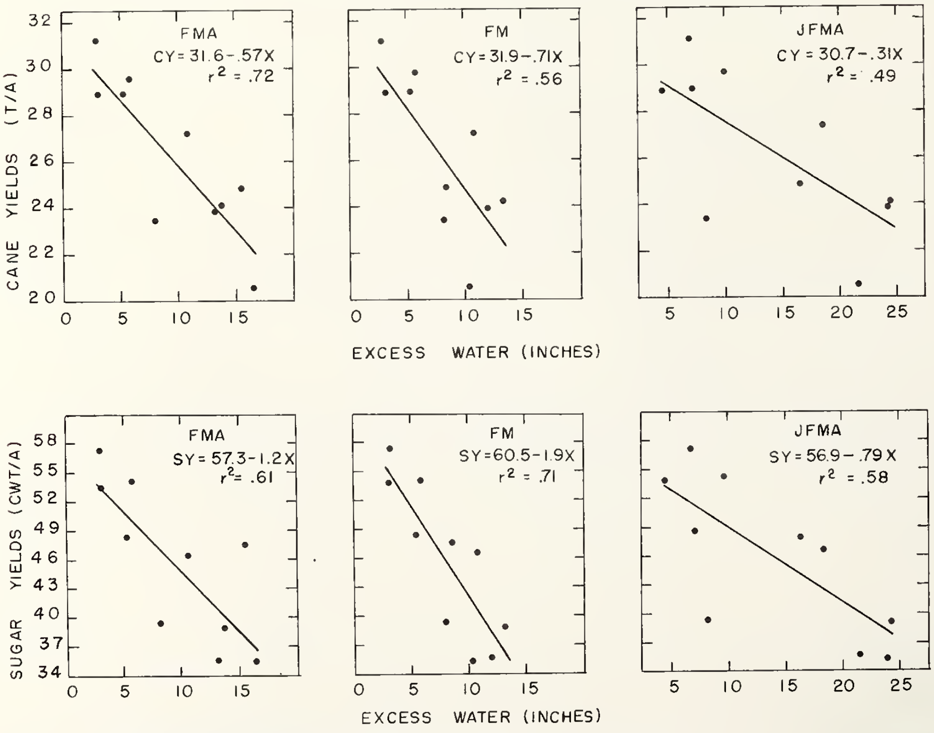

Fig. 5. Relationship between average parish cane and sugar yields and excess water during various months. Assumption Parish, Louisiana. 1963-1973.

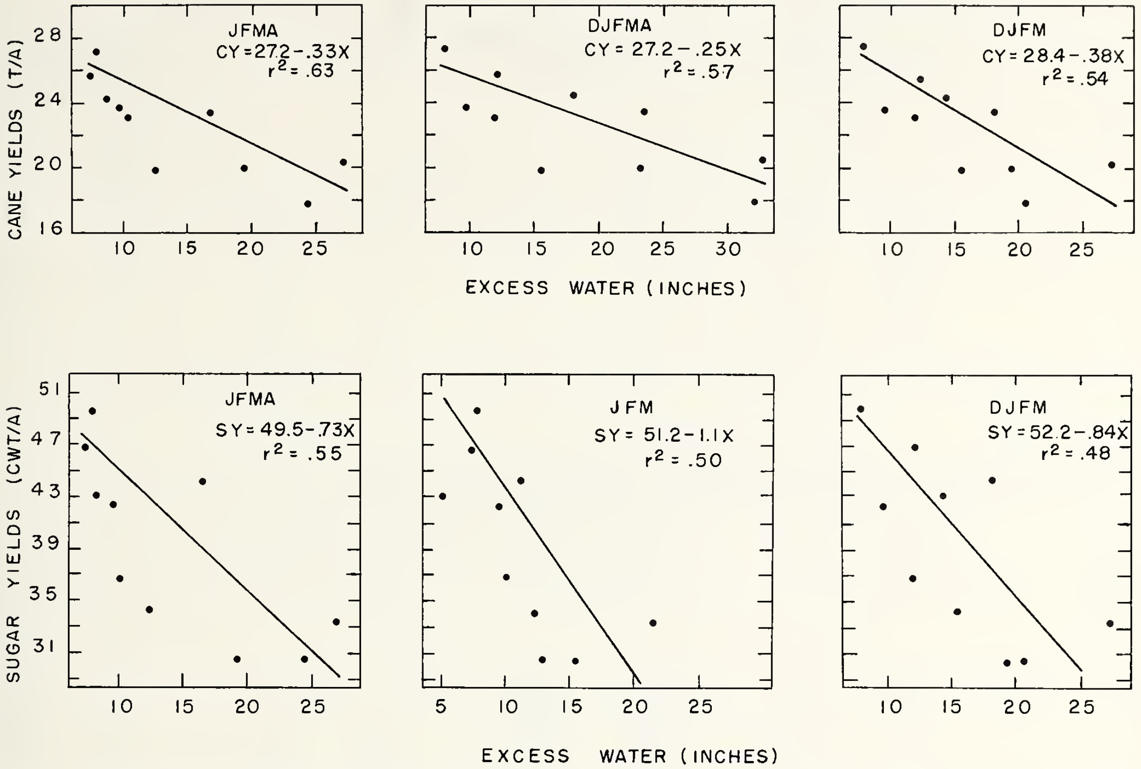

Fig. 6. Relationship between average parish cane and sugar yields and excess water during various months. Terrebonne Parish, Louisiana. 1963-1973.

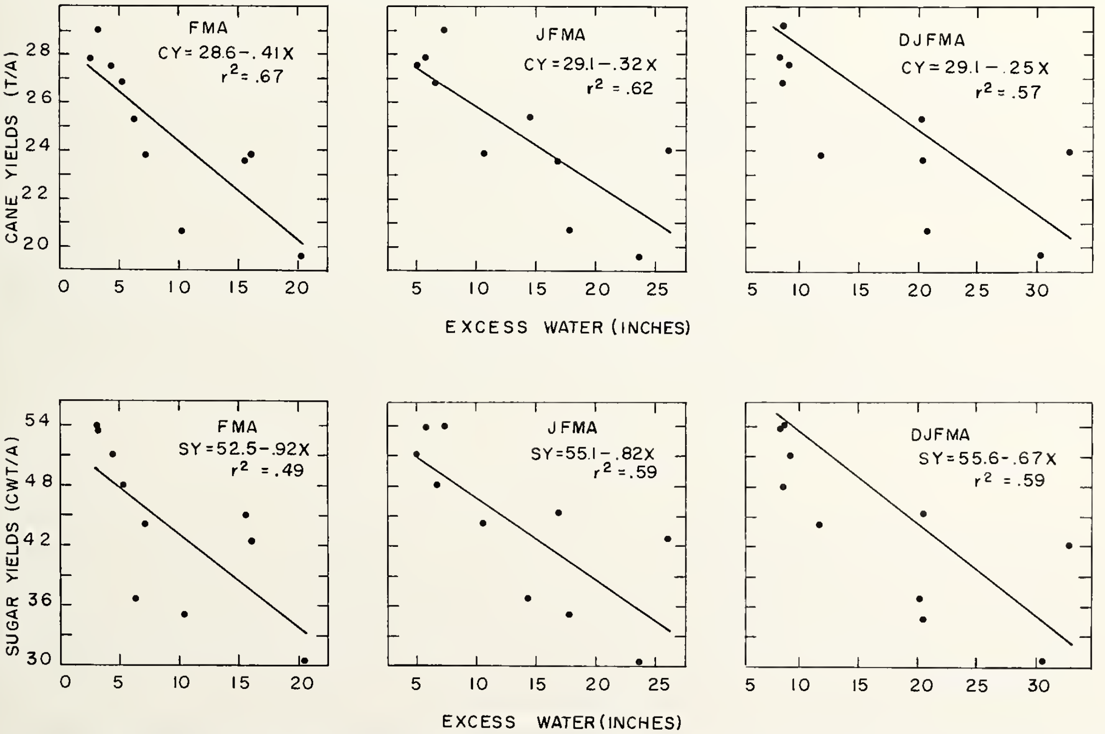

Fig. 7. Relationship between average parish cane and sugar yields and excess water during various months. St. Mary Parish, Louisiana. 1963-1973.

Table 1. Coefficients of determination, r^2, and regression coefficients, b, from linear regression of water excess and cane yields during various months. 1963-1973.

Time (months)	Parish							
	West Baton Rouge		Assumption		Terrebonne		St. Mary	
	r^2	b	r^2	b	r^2	b	r^2	b
A							.42	-.57
M							.49	-.76
MA	.50	-.41						
FMA	.58	-.35	.72	-.57	.46	-.36	.67	-.41
FM	.65	-.54	.56	-.71	.43	-.95	.55	-.62
JFM	.50	-.31			.47	-.44		
JFMA	.56	-.27	.49	-.31	.63	-.33	.62	-.32
DJFMA	.58	-.21	.41	-.25	.57	-.25	.57	-.25
DJFM	.59	-.26			.54	-.38		
DJ					.42	-.43		

Table 2. Coefficients of determination, r^2, and regression coefficients, b, from linear regression of water excess and sugar yields during various months. 1963-1973.

Time (months)	Parish							
	West Baton Rouge		Assumption		Terrebonne		St. Mary	
	r^2	b	r^2	b	r^2	b	r^2	b
M							.43	-183
MA	.50	-105					.47	- 79
FMA	.44	- 78	.61	-122			.49	- 92
FM	.63	-134	.71	-186			.43	-145
JFM	.58	- 84	.49	- 81	.50	-107	.42	- 84
JFMA	.53	- 67	.58	- 79	.55	- 73	.59	- 82
DJFMA	.51	- 51	.49	- 63	.45	- 53	.59	- 67
DJFM	.60	- 67	.41	- 62	.48	- 84		
DJF	.44	- 69						
DJ	.44	-101			.40	- 98		

February and March were the months in which excess water was most frequently correlated with decreased cane yields in this study. These two months are included in every graph in Fig. 4 through 7 and are shown frequently in Tables 1 and 2. Wet soil during these months may cause an aerobic condition or favor soil pathogens which adversely affect the plant population, vigor, and the development of surviving plants.

These data suggest the need for management practices or systems that will reduce or alleviate problems caused by excess water in the sugarcane area of Louisiana. Most sugarcane farmers have long recognized the need for surface drainage and many acres are precision graded each year. This practice, however, does not completely solve the problem. Excess water can cause the water table in the soil to rise into the root zone of sugarcane, creating a serious problem. Experiments at Baton Rouge and Houma have shown that subsurface drainage was very effective in preventing damage by high water tables in Mhoon silty clay soil. This resulted in an increase in cane and sugar yields as well as stand longevity (1, 2).

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DRAINAGE FOR SUGARCANE IN LOUISIANA: A REVIEW

C. R. Camp
USDA, ARS
Baton Rouge, Louisiana

ABSTRACT

The need for adequate drainage of sugarcane land has been recognized for at least the past 120 years. High rainfall frequency and annual amount combine with slowly permeable soils to create a severe problem; surface drainage has received much attention since initial recognition of the drainage problem. Various cultural practices, such as planting on 18-inch ridges, have proved successful and generally remain in practice today. However, other surface-drainage procedures have changed through the years. Initially, parallel, lateral drainage ditches were spaced 100 to 250 feet apart and ranged from 18 to 36 inches deep. As tillage and other management practices altered the soil surface to create additional drainage problems, split ditches were placed between existing lateral ditches. Later, land grading i.e., turtlebacking, was introduced to provide better drainage of surface depressions and better water movement through furrows and quarter drains to the lateral drains. In the past 10 to 20 years, precision surface grading has provided surface drainage, while it has also eliminated many lateral ditches. Subsurface drainage was installed in this region as early as 1887, and farm systems were installed as late as 1914. Most of these failed, because adequate outlets were not maintained and sediment filled the drain lines. An experiment was conducted between 1934 and 1937 to determine the response of sugarcane to both subsurface and open-ditch drainage, both with pumped outlets. Another experiment, using corrugated polyethylene drainage tubing, was started in 1972 and is continuing at the present time. Results to date indicate a high potential for increased sugar yields.

DISTRIBUTION OF CARBOHYDRATES AND POTASSIUM IN SUGARCANE PARTS[1]

J. E. Irvine
U. S. Sugarcane Field Laboratory, ARS, USDA,
Houma, Louisiana 70360

ABSTRACT

Samples of field-grown plant cane of CP 65-357 were harvested in November and December. The samples were divided into 11 parts: dead leaves, green leaf blades, sheaths, leaf roll, soft stem tips, four 60 cm segments, stubble pieces, and roots. The sub-samples were milled and the extracted juice was frozen and later analyzed for starch, soluble polysaccharides (gums), sucrose, glucose, and fructose. The starch concentration was highest in the leaf blades and increased dramatically during the day. Soluble polysaccharides were high in both green and dead leaves. Reducing sugars were high in the leaf roll and stem tip. Sucrose was detectable in all parts but was most abundant in the lower half of the stalk. Potassium content was lowest in roots and increased upward within the plants, the highest concentrations being found in the tops. Stubble pieces were higher in sucrose than the upper 60 cm segment, and slightly lower than the remaining 120 cm. Millable cane was 66% tops and 19% of the entire plant as harvested. Because the high content of starch, gums, and reducing sugars can lower sucrose recovery, cane tops constitute a most damaging form of cane trash.

INTRODUCTION

Sugarcane delivered to the mill is traditionally divided into millable stalks and trash; payment includes a penalty for trash (1). This penalty, based on weight, makes no allowance for the type of trash, whether green tops, dead leaves, stubble, or mud, although trash type does affect milling characteristics (12). The worldwide move from hand to mechanical harvesting assures increasing amounts of trash in cane sent to the mills.

The constituents of the millable stalks have been described in detail and reviews are available (4, 13). Water, sucrose, and fiber are the main constituents of millable stalks, and dextrose, levulose, gums, starch, amino and organic acids, proteins, colorants, and minerals are minor constituents. Their effects on sucrose recovery and the quality of refined sugar have been extensively studied. The constituents of trash components have not been investigated so thoroughly, but such studies have included colorants (6) and potassium concentration (9).

The purpose of the present study was to survey the cane plant in terms of its component parts and the constituents that might affect sucrose recovery.

MATERIALS AND METHODS

Entire plants of the variety CP 65-357, including tops, stalks, dead leaves, stubble, and attached roots, were harvested in November and December, 1975. Sampling was done on 9 separate dates, and samples were taken at 6 and 9 AM, 12 N and 3 and 6 PM. No sampling time was represented by less than 5 samples; 3 were sampled 8 times, giving a total of 34 samples. Harvesting samples was avoided during cloudy periods.

In sampling, the entire stool was dug, freed of excess dirt, and rapidly transported to the laboratory. The plant was divided into green leaf blades, leaf sheaths, leaf roll, dead leaves, stem tip (terminal bud and elongating internodes), the 1st (upper), 2nd, 3rd and 4th 60 cm segments of millable stalk, stubble (underground parts of stalks and developing shoots), and those roots attached to the stubble. Stalks that were longer than 240 cm were trimmed at the base. Each sub-sample was weighed and the stalk and stubble samples were ground on a sample mill (25,000 psi); all other sub-samples were finely chopped and the juice was extracted by a hydraulic press (20,000 psi). Extracted juice was weighed, bagged in polyethylene, and frozen for later chemical analyses.

Juice samples were analyzed for brix, sucrose, and purity by traditional methods (13). Sucrose, dextrose, levulose, and other sugars were assayed by high pressure liquid chromatography. Starch concentration was measured by the iodometric technique (2), which is rapid but gives values approximately one-half of true values (3). Soluble polysaccharides were measured colorimetrically with phenol-sulfuric acid after alcoholic precipitation (16). Potassium ion concentrations in juice samples were determined by a specific ion electrode.

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[1] A contribution from ARS, USDA, in cooperation with the Louisiana Agricultural Experiment Station.

RESULTS AND DISCUSSION

The relative weights of the various sugarcane plant parts are presented in Table 1. Of the entire plant, only 66.1% is millable stalk, the remaining 33.9% is defined as trash (1). The portion defined as millable stalk, when divided into 4 sections of equal length, showed a progressive increase in weight from top to bottom. This is due to an increase in diameter and to an increase in sucrose content. Of the part classified as trash, a portion (10.6% of total) seldom reaches the mills; this is the stubble and attached roots. The greatest single component of cane trash was the green leaf blades (11.1% of the total) and the entire top (blades, sheaths, leaf roll and stem tip) accounted for 19% of the entire plant. Dead leaves (both blade and sheath) accounted for but 4.3% of the total; this is an underestimate because only attached leaves were samples and the dead leaves were very dry at all sampling dates. Imbibition of rain water would increase the percentage of dead leaf material.

Table 1. Sugarcane parts, their proportion, juice extraction, carbohydrate, and potassium content.

			Chemical constituent, mg/ml juice					
Part	Weight	Extraction	Starch	Gums	Sucrose	Dextrose	Levulose	Potassium
	%	%						
Blade	11.1[1/]	40.6	.320	5.05	7.72	6.76	3.75	4.55
Sheath	4.3	38.6	.050	3.84	14.20	5.92	3.33	4.42
Leaf roll	2.0	48.2	.084	5.69	6.85	13.60	7.56	5.00
Stem tip	1.6	47.6	.077	5.54	14.82	17.52	17.94	4.07
Millable stalk								
Top 60 cm	14.0	69.3	.101	1.70	103.46	9.84	6.88	2.59
2nd 60 cm	14.8	71.3	.081	1.40	154.88	6.08	5.38	2.56
3rd 60 cm	17.8	73.6	.055	1.31	181.85	4.09	3.63	2.15
4th 60 cm	19.5	71.1	.043	1.24	185.10	2.80	3.06	1.91
Stubble [2/]	9.3	65.3	.059	2.01	152.50	5.94	3.01	1.43
Roots[3/]	1.3	27.2	0	1.28	8.76	2.50	1.25	0.52
Dead leaves	4.3	37.1[4/]	0	6.50	0	0	0	1.02
LSD 5%	2.8	5.2	0.040	0.39	9.15	2.37	1.83	0.67

1/Each number is the average of 34 samples.
2/Stubble consisted of below ground parts of stalks and new shoots washed free of soil.
3/Roots were root stumps attached to stubble stool when pulled from ground. Roots were washed and no attempt was made to secure the entire system.
4/Dead leaves were saturated with distilled water. Extraction datum does not represent the true value.

Juice extraction, expressed as percent fresh weight, was highest in stalk segments and less in the various trash components. Among these, extraction was highest in the stubble, less in the stem tip and leaf roll, still less in the leaf blade and sheath, and least in the roots. The juice extraction of cane tops was only 60% that of the millable stalks.

Of the chemical constituents studied, only starch varied significantly (1% level) with the time of day that the sample was harvested. In the parts assayed for starch, this variation was striking in the leaf blades (Fig. 1), and influenced the variation in the entire cane top. No diurnal variation in starch content was detectable in any part other than the green leaf blades. Obviously due to the accumulation of photosynthate during the day and its removal at night, the diurnal variation in starch may affect sugar recovery at the mill.

In processing, when juice exceeds 71C, starch is "pasted", or solubilized, and rather than being eliminated with the mud in clarification, it remains in the clarified juice, concentrating as the juice is evaporated when it increases viscosity and inhibits crystallization. Harvesting systems which do not effectively remove tops or green leaf blades add to the starch load in clarification. Cane tops harvested in the morning hours would have the lowest starch content (Fig. 1) and those harvested in the afternoon or evening would have the highest. Cane tops harvested on sunny days may have more starch than those harvested on cloudy days.

Soluble polysaccharides (gums) were detected in all parts of the sugarcane plant. Highest gum values were obtained from leaves, either green or dead. The presence of water-soluble gums in dead leaves exposed to rain was a surprise. That gums in dead leaves may be a deterioration product is supported by the discovery of Roberts (15) of many unusual carbohydrate fractions in extracts and gum hydrolysates from dead leaves. Gums were less abundant in the millable stalk, and stalk segments showed a decreasing concentration from top to bottom of the stalk. Stubble pieces were higher in gums than were stalks and roots, due to the presence of young shoots, whose morphology and composition are similar to those of the tops.

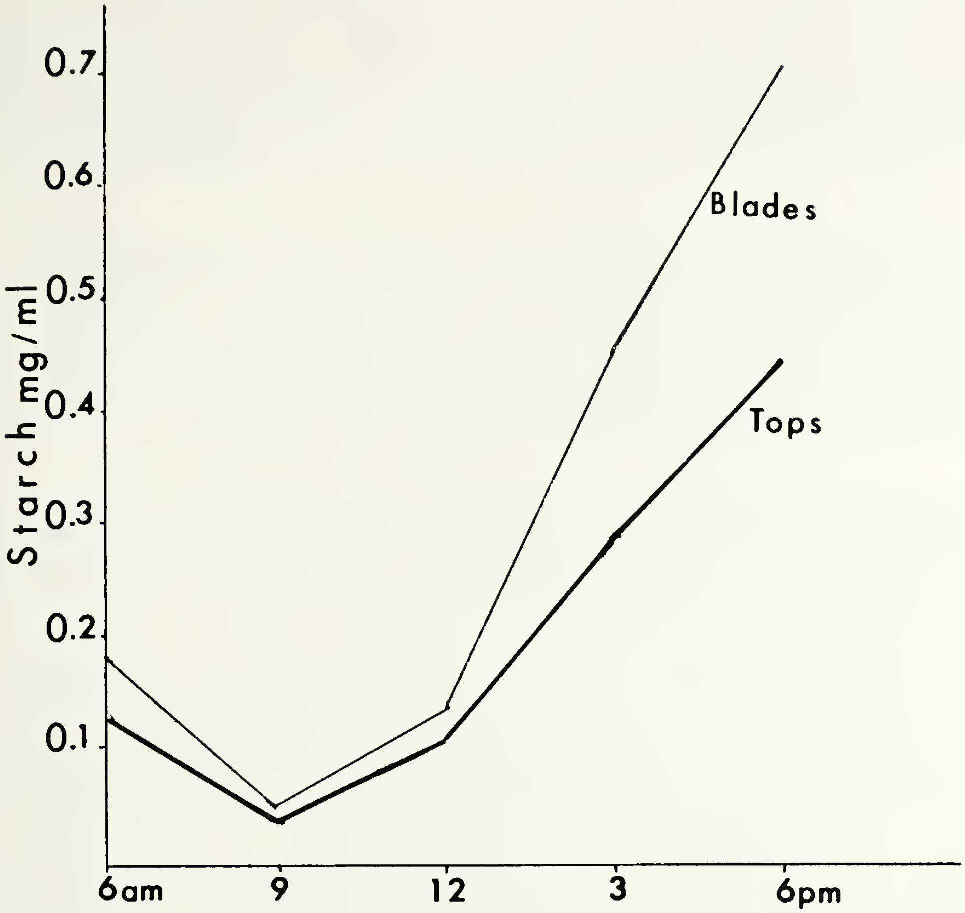

Figure 1. Diurnal change in iodometric starch in sugarcane leaves and tops var. CP 65-357.

Sucrose was detected in all parts of the cane plant except the dead leaves. It was the most abundant carbohydrate in all parts except these and the leaf roll. Sucrose was lowest in the leaf roll, green leaf blades, and roots, and was highest in the bottom 60 cm stalk segments. High concentrations of sucrose were found in the stubble pieces, comparable to the lower 75% of the millable stalk. Sucrose concentrations in the stubble were diluted by the presence of young shoots, whose sucrose content was similar to that of cane tops. Clumps of stubble inadvertently delivered to the mill by mechanical harvesting systems have been classified as trash (1). These data (Table 1) indicate that the quality of the stubble, excluding adhering mud, is higher than the upper part of the stalk and its classification as trash needs reexamination.

The ratio of sucrose to invert sugars (dextrose and levulose) varied considerably within the cane plant. This ratio is significant in determining potential sugar and molasses yields. In the cane top, this ratio was 0.61, while in the millable stalk, it was 14.97. Within the millable stalk, the sucrose/invert ratio increased from 6.19 in the upper segments to 31.59 in the lower 60 cm segments.

Moderate in leaf blades and sheaths, the dextrose concentration was highest in the leaf roll and stem tip where cell division and elongation occur. In the millable stalk, dextrose was highest in the top 60 cm and progressively decreased in successively lower segments. The stubble showed a higher dextrose content, as it did of starches and gums, due to the young shoots included in the sample. Dextrose was lowest in the roots, and none was observed in the dead leaves at the level of detection employed (0.05 mg/ml).

The ratio of dextrose to levulose (D/L ratio), which can affect the accuracy of polarimetric sucrose analyses, has been reported to vary with variety and season (11). The D/L ratio also varies within the plant; calculations made from the data in Table 1 show a range of 2.0 to 0.9. The D/L ratio was higher in the roots, stubble, blades, sheaths, and leaf roll, and was lower in the stem tip and decreased progressively down the stalk. The high invert content of cane tops plus the high D/L ratio could cause false high polarization readings in sucrose determinations, should sufficient tops be delivered to the mills. It is unlikely that a low D/L ratio would cause false low pol readings, because low D/L ratios are associated with low levels of invert sugars and high levels of sucrose; this association occurs in varieties and seasons (11) as well as within the plant (Table 1).

The levulose content of the various parts was similar to that of dextrose. Levulose was highest in the stem tip and leaf roll, and lowest in the roots. Levulose also decreased progressively in lower stalk segments, but as the change in the D/L ratio showed, levulose decreased at a slower rate than dextrose, so that in the basal 60 cm segments, levulose was slightly greater in concentration than dextrose. These were the only parts to show a D/L ratio of less than 1. No levulose was detected in the dead leaves.

These data show general agreement with models of sugar transport and storage. Products of photosynthesis are translocated immediately (10) as hexoses or as sucrose (8, 10), or they may be stored temporarily as starch (these data) in the blades, when the rate of photosynthesis exceeds the rate of sucrose removal by translocation. Movement of sugars is achieved by a light-driven system and an ancillary system (8, 10) and proceeds downward at a rate of 1 to 2 cm per minute (10). Sucrose can move to all parts, even other stalks of the same stool (8) but generally accumulates in the stalk, lower internodes being highest and upper internodes lowest in sucrose content. Several mechanisms have been proposed for moving sucrose into storage cells against a concentration gradient (8). They include the conversion of sucrose to hexoses by free space invertase, with hexose transport across the cell membrane and subsequent reconversion to sucrose and storage in the cell vacuole.

Potassium was found in all parts of the plant, including the dead leaves. The potassium ion concentration was highest in the tops and lowest in the roots; this gradient was repeated throughout the stalk. The capacity of plants to accumulate potassium against a concentration gradient is confirmed by these data and there is almost a tenfold increase in potassium ion concentration from the roots to the leaves. Potassium is the major ash constituent of sugarcane. It is not precipitated in clarification but increases in concentration in processing (13), and high potassium levels are associated with lowered sucrose recovery and high purity in the final molasses.

Sucrose recovery is not simply a function of concentration, but is affected by fiber, extraction, resorption, and by the presence of substances that inhibit crystallization. From the extraction data in Table 1, the sucrose content of millable stalks was calculated to be 11.3%, and that of the tops was 0.4%. Not all of this can be extracted from the stalks because after passage through the mill train, the bagasse from stalks contains about 3% sucrose. If stalks and tops were milled together, the additional bagasse formed from the tops would resorb sucrose expressed from the stalks, causing losses. The juices expressed from the tops also have the same nonsucrose solids that inhibit crystallization and are major molasses constituents; these are dextrose, levulose, gums, starch, and potassium. From the data of Table 1, the percent of these crystallization inhibitors in tops and in millable stalks was calculated (Table 2). The net effect of milling cane with tops is to reduce the available sucrose and increase the amount of nonsucrose solids. The empirical rule of Winter's, restated, says that nonsucrose solids will prevent 40% of their weight in sucrose from crystallizing (7). From the data in Table 2, calculations show that a ton of millable cane would contain 102 kg (225 lb) of sucrose together with 8.6 kg (19 lb) of nonsucrose solids, while a ton of tops would contain 3.6 kg (8 lb) of sucrose and 9.1 kg (20 lb) of nonsucrose solids. Using Winter's factor (7), the loss of sucrose from the nonsucrose solids in the stalks and the tops (given equal weights) would be 3.3 and 3.6 kg (7.2 and 8.0 lb), respectively. Similarly, a ton of cane with tops attached would contain 76.3 kg (168.3 lb) of sucrose and 3.5 kg (7.7 lb) of this would be lost to nonsucrose solids.

Table 2. Relation of sucrose and sucrose crystallization inhibitors in millable stalks and tops of variety CP 65-357.

		Anti-crystalizers				
Source	Sucrose	Dextrose	Levulose	Gums	Starch	Potassium
	%	%	%	%	%	%
Tops	0.40[1/]	0.35	0.25	0.20	0.010	0.19
Millable cane	11.26	0.38	0.32	0.10	0.005	0.16

[1/] Numbers are calculated from Table 1 using the constituent value, the extraction of each part and the weighted averages of the 4 stalk segments for cane, and the blade, sheath, roll and tip for tops.

Winter's factor treats all nonsucrose solids as equal in the inhibition of sucrose crystallization, but other workers (5) have shown that inhibition increases with increased molecular weight in some instances. Thus, starch and gums, high molecular weight polymers, may cause more inhibition than the simple sugars or mineral constituents. Because sugarcane tops have twice the starch and gums (Table 2) of the millable stalks, their contribution of nonsucrose solids would more effectively inhibit crystallization.

These data suggest that those parts of the cane plant that are defined as trash (1) do not behave only as inert filler, but cause sucrose losses by resorption (except stubble), or by adding nonsucrose solids to the extracted juice. The total effect depends on the sucrose content of the trash, its extraction, and the nature and action of the solids it contributes to the mixed juices. The data imply that hand-cut and cleaned cane is the best raw material for the sugar mill, and that harvesting systems that include increasing amounts of cane trash deliver raw material of decreasing quality. That sugar can be made (with difficulty) from cane with all tops intact has been demonstrated (Polack, 14), but the economic balance has yet to be determined.

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SPECIFIC GRAVITY, FIBER, AND MINERAL CONTENT OF CP 56-59 AND CP 63-588 SUGARCANE IN FLORIDA

G. Kidder[1], N. I. James[2], and G. J. Gascho[1]

ABSTRACT

Plant and ratoon crops of commercially grown CP 56-59 and CP 63-588 were sampled in November 1975 to determine the influence of crop, variety, and location on specific gravity and percent fiber of sugarcane. Hand-stripped, millable stalks were collected from three locations: sandy soils west of Lake Okeechobee, muck soils south of Clewiston, and muck soils east of Belle Glade. Neither crop, variety, nor location affected specific gravity. Average fiber contents of CP 56-59 and CP 63-588 were 11.75% and 10.04%, respectively. Fiber was highest (11.34%) on sand land and lowest (10.53%) on muck east of Belle Glade. For cane with the same brix and sucrose in the first expressed juice, each percentage increase in fiber decreased the normal juice extracted by 1.5 percentage points and decreased the amount of recoverable sugar by 2%. Crop (plant or first ratoon) did not influence fiber content and no interactions were found. Chemical analyses were performed on millable stalks of ratoon CP 56-59. Cane grown on sand lands was higher in P and lower in N, K, and Mg than that grown on muck.

INTRODUCTION

Sugarcane in Florida is presently grown on both sand and organic soils. Producers have expressed concern about apparent high fiber and variable specific gravity in cane grown on the sand.

Specific gravity of sugarcane (ratio of weight of cane to weight of equal volume of water) is not often measured. Evans (4) discussed the influence of pithiness on specific gravity and reported ranges of 0.703 to 0.848 and 0.948 to 1.065 for pithy and nonpithy portions of stalks, respectively. Miller and James (6) found average stalk specific gravity of 52 sugarcane clones to be 1.06 with a range of 0.87 to 1.15. Specific gravity was not an important yield component in that population.

Arceneaux *et al*. (2) showed differences in fiber content due to location and crop in Louisiana. Snow (7) found no difference in the hard fiber (rind and vascular tissue) to pith (soft, inner stalk tissue) ratio when cane was grown at different geographical locations and on different soil types in Florida. He did not report fiber content.

Andreis (1) reported plant nutrient content of millable stalks and trash for four Clewiston (Cl) varieties grown on Florida organic soils and found that, except for higher nitrogen, the results were similar to those observed in Louisiana. There is no information on nutrient content of millable stalks for cane grown on sand in Florida. Knowledge of the amount of mineral elements in millable sugarcane stalks will aid in establishing the levels of nutrients removed by harvesting and in determining the nutrient requirements of a sugarcane crop.

We report here specific gravity and fiber content for plant and first ratoon crops of two varieties of sugarcane grown at three locations in Florida. Mineral content of the ratoon crop of one variety at the three locations is also reported.

MATERIALS AND METHODS

Four 6-stalk samples were obtained from each of four fields of two varieties, CP 56-59 and CP 63-588, in plant and first ratoon crops at each of three locations. Hand-stripped samples were collected on November 17 and 18, 1975 by taking two stalks from each of three stools near the four corners of fields that ranged in size from 4 to 16 hectares. Location 1 was on sand from two farms west of Lake Okeechobee, one 25 km north and the other 15 km south of Moore Haven; plant-crop fields of CP 56-59 were not available at the same farm where all other samples for Location 1 were obtained. Location 2 was on muck 25 km south of Clewiston and Location 3 was on muck 25 km east of Belle Glade.

Samples were divided to provide two subsamples each containing the equivalent of two stalks. Stalks were cut into three pieces of equal length. The top segment of one stalk, the middle segment of a second, the bottom segment of a third, and comparable segments from the fourth through the sixth stalk constituted Subsample 1. The middle segment of the first stalk, the bottom segment of the second, top segment of the third, and comparable segments from the fourth through the sixth stalk constituted Subsample 2. Remaining stalk segments were discarded.

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[1] Agricultural Research and Education Center, Belle Glade, FL 33430
[2] U. S. Sugarcane Field Station, Canal Point, FL 33438

Specific gravity was determined on Subsample 1 by water displacement. The subsample was weighed, immersed in water, and the weight of the displaced water was determined. Specific gravity was calculated by dividing fresh weight by weight of displaced water.

Fiber content of Subsample 2 was determined as percent of fresh weight, as is customary in sugarcane work. The stalk segments were passed through a Jeffco Cutter-Grinder to macerate the material without juice loss. Duplicate 200 to 300 g aliquots of macerated material were placed in fine-mesh cotton bags and weighed. The bags were washed and rinsed twice in automatic washing machines with vertical agitators to remove the soluble solids. Wash and rinse water temperatures were ca. 60 C and 21 C respectively. After washing, the bags were placed in a forced air dryer at 60 C for 12 hours and then maintained at 105 C until dry. Fiber percentage was calculated as (dry weight/fresh weight) x 100.

In addition, 50 to 100 g aliquots of macerated material from Subsample 2 were dried at 70 C, weighed to determine moisture content, and ground in a stainless steel Wiley mill in preparation for chemical determinations.

Due to laboratory limitations, not all samples were analyzed chemically. The plant material of ratoon CP 56-59 was selected for analysis and wet-digested using perchloric acid. Concentrations of K, Ca, Mg, Cu, Mn, Zn and Fe were determined by atomic absorption spectrophotometry and P was determined by colorimetry. Nitrogen was determined by semi-micro Kjeldahl. Silicon was determined by atomic absorption of a solution prepared by fusion with NaOH.

The data were analyzed as a three-way factorial with location, variety, and crop considered as factors. Fields, samples, and subsamples were nested within these classifications. Multiple regression analyses using least squares procedures for fitting constants (3) were performed with the aid of a computer.

RESULTS AND DISCUSSION

There were no significant differences in specific gravity due to location, variety, or crop (Table 1). Mean specific gravity ranged from 1.097 to 1.106 (Table 2), only a 1% difference. These values are approximately equal to the 1.06 determined previously for 52 clones at Canal Point (5). It is unlikely that specific gravity of cane is a factor in differential tonnage yields under the field conditions tested. Specific gravity may be more important in early flowering varieties where pithiness sometimes develops. Pithiness was not observed in the canes tested in this study.

Table 1. Summary of analysis of variance for specific gravity and fiber content.

Source	df	Specific gravity	Fiber
		- Mean squares x 10^{-3} -	
Location	2	0.6414	21.5412**
Variety	1	0.1252	280.7991**
Location x variety	2	0.0530	1.0634
Crop	1	0.3314	1.0137
Location x crop	2	0.8098	1.1229
Variety x crop	1	0.3502	1.1148
Location x variety x crop	2	0.4258	2.9021
Fields/classifications	36	0.4411	1.2876
Samples/fields	144	0.3809	1.5055
Subsamples/samples	192	[1]	0.3630

[1] No subsamples for specific gravity.
** Significant at the 0.01 level.

Table 2. Specific gravity of trash-free millable cane stalks for two varieties at three locations.

Location[1]	Variety CP 56-59	 CP 63-588	Mean[2]
1	1.103[3]	1.104	1.103
2	1.097	1.101	1.098
3	1.106	1.105	1.106
Mean	1.102	1.103	

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[1] Location 1, sand west of Lake Okeechobee; Location 2, muck south of Clewiston; Location 3, muck east of Belle Glade.
[2] Means were not significantly different at the 0.05 level.
[3] Mean of 32 determinations.

Mean percent fiber (Table 3) was higher on sand at Location 1 than on mucks at Locations 2 and 3. At the 0.10 level of significance, fiber content was different at the two muck locations. CP 56-59 was higher in fiber content than was CP 63-588. No differences in fiber content were recorded between plant and first ratoon. Interactions were not significant, indicating that fiber content responded the same in the plant and first ratoon crops of the two varieties at each location.

Table 3. Fiber content in trash-free millable cane stalks for two varieties at three locations.

Location[1]	Variety CP 56-59	 CP 63-588	Mean
	- - - - - - - - - - - - - - -	percent - - - - - - - - - - - - -	
1	12.10[2]	10.65	11.38a[3]
2	11.74	9.85	10.80b
3	11.41	9.66	10.53b
Mean	11.75a	10.05b	

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[1] Location 1, sand west of Lake Okeechobee; Location 2, muck south of Clewiston; Location 3, muck east of Belle Glade.
[2] Mean of 64 determinations.
[3] Means followed by a common letter are not significantly different at 0.05 level Duncan's multiple range test.

Multiple regression analysis showed that, of the total explained variation in fiber, 3% was accounted for by location, 20% by cane moisture content, and 43% by variety. Thus, the differences in fiber content attributed to location in the analysis of variance (Table 1) are mostly due to the moisture differences of the cane at the three locations and not to location *per se*. If fiber content were expressed as percent dry matter rather than the traditional percent fresh weight, fiber would not be affected by the degree of hydration. In this report, fiber is expressed as percent fresh weight and the less hydrated cane from sand soil showed higher fiber contents than the more hydrated cane from the organic soil locations.

Regression analysis of data collected at Canal Point (5) showed that an increase of 1.0 percentage point in fiber content decreased normal juice extraction by 1.5 percentage points and decreased the amount of recoverable sugar by 2% when brix and sucrose content of primary juice were equal. In addition to this loss of recoverable sugar, there are higher milling costs associated with high fiber.

The precision of this survey was adequate to point out where differences in fiber could be expected. Increased precision would require sampling of additional fields in each location-variety-crop combination.

Results of elemental analyses of millable cane stalks of first ratoon CP 56-59 are shown in Table 4. Nitrogen, K, and Mg concentrations were higher and P concentration was lower on the mucks than on the sand. Calculation of nutrient concentration on a "lb/ton of cane" basis indicated lower concentrations for N and P but higher concentrations for K than those obtained by Andreis (1). However, our data do not include nutrients in the trash. These data will help establish the levels of nutrients expected to be lost by harvesting in cane grown under the conditions described.

Table 4. Elemental concentrations in trash-free millable stalks of first ratoon CP 56-59 sugarcane.

Location[1]	Elements									
	N	P	K	Ca	Mg	Si	Cu	Mn	Zn	Fe
	percent dry weight						ppm dry weight			
1	0.23b[2]	0.058a	0.82b	0.107	0.060b	0.03b	3	29a	20	105
2	0.43a	0.037b	1.31a	0.108	0.098a	0.04b	3	24ab	20	116
3	0.38a	0.043b	1.24a	0.109	0.108a	0.12a	3	10b	15	101

[1] Location 1, sand west of Lake Okeechobee; Location 2, muck south of Clewiston; Location 3, muck east of Belle Glade.

[2] Mean of 8 determinations. Column means followed by a common letter are not significantly different at 0.05 level Duncan's multiple range test.

ACKNOWLEDGMENTS

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RIPENING STUDIES WITH GLYPHOSINE IN LOUISIANA SUGARCANE[1], [2]

B. L. Legendre and F. A. Martin
U.S. Sugarcane Field Laboratory, Houma, LA 70361,
and
Louisiana Agricultural Experiment Station
Baton Rouge, LA 70803

ABSTRACT

The ripening effect of glyphosine on sugarcane was evaluated during 1974 and 1975 at 41 sites in Louisiana. Glyphosine (3.0 lb a.i./acre) was applied by airplane in 5 gallons of spray mixture per acre to either plant or stubble crops of four commercial varieties, CP 48-103, CP 61-37, L 62-96, and NCo 310. Five to seven weeks after treatment, response to glyphosine was evaluated by measuring recoverable sugar/ton, tons cane/acre, and recoverable sugar/acre. Glyphosine improved recoverable sugar/ton by 6.7%, reduced tons cane/acre by 2.2%, and improved recoverable sugar/acre by 4.8% as an average of all tests. Results for individual tests were highly variable. Overall the gains in recoverable sugar/acre were 5.9, 3.3, 8.6, and 1.8% for CP 48-103, CP 61-37, L 62-96, and NCo 310, respectively. Due to the generally low level of response in increasing recoverable sugar/A and the current economic situation, no general recommendation was given for its use in Louisiana. However, several special circumstances are cited in which glyphosine may be a useful tool in improving the quality of harvested sugarcane.

INTRODUCTION

The potential of growth regulating chemicals in agricultural crops has been increasingly recognized in recent years (1, 2, 9, 10, 11, 12). Chemical agents have been developed exclusively for specific use on sugarcane. An example of such a compound is glyphosine /N,N-bis(phosphonomethyl)glycine/. Preliminary results showed glyphosine to be effective in increasing the level of sucrose in Louisiana sugarcane (3, 4, 6, 7, 12). However, these studies showed variable responses, both in terms of sucrose content of cane and in yield of sucrose per unit area of land.

In 1974 and 1975, field applications were made by fixed wing aircraft using glyphosine as a chemical ripener. The effects of glyphosine were tested on yield of recoverable sugar per ton of cane, yield of cane per acre, and yield of recoverable sugar per acre on four varieties of sugarcane widely grown in Louisiana. This paper reports the findings of these investigations.

MATERIALS AND METHODS

Treatment plots were fields 0.5 to 15 acres in size containing one of four sugarcane varieties, CP 48-103, CP 61-37, L 62-96, or NCo 310, in either the plant cane or stubble crop. Field locations, 41 in all, were determined by mutual agreement between cooperating growers and a representative from the manufacturer of glyphosine. Data were obtained from replicated subplots within a treatment unit from the 41 locations. A commercial formulation of glyphosine was applied by airplane 5 to 7 weeks before harvest (5 gallons containing 3 lb a.i./A). An adjacent field or strip was used as an untreated check. At harvest, 15-stalk samples were collected from each of six to eight subplots within treated and untreated areas. At 25 locations, the samples were removed from standing cane. In these samples the stalks were cut flush with the ground, stripped, topped through the apex, weighed, and milled once through a 3-roll mill. At the remaining 16 locations, samples were pulled at random from the heap row after mechanical cutting and topping; these canes were stripped, weighed, and milled. Any tops remaining on collected stalks were cut at the apex and discarded.

For each juice sample, brix was determined by hydrometer, apparent sucrose by polarization, and apparent purity as the ratio of apparent sucrose to brix (8). From these results, the yield of recoverable sugar per ton of cane was calculated by a method previously described (5). The yield of cane/A was calculated by multiplying the mean stalk population/A by the mean stalk weight. Finally, the yield of recoverable sugar/A was calculated by multiplying recoverable sugar per ton by yield of cane/A. Differences between treatments at each of the 41 locations were analyzed through the use of the analysis of variance. Locations were then combined and the data analyzed through the use of the analysis of variance by variety, geographical area, and method of harvest (hand vs. machine cut).

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[1] A contribution from ARS, USDA, in cooperation with the Louisiana Agricultural Experiment Station.

[2] This paper reports the results of research only. Mention of a growth regulator in this paper does not constitute a recommendation for use by the USDA nor does it imply registration under FIFRA as amended.

RESULTS AND DISCUSSION

Previous tests had shown that the varieties CP 48-103, CP 61-37, L 62-96, and NCo 310 responded best to glyphosine treatment in Louisiana (3, 6, 7). In the present tests (Table 1), glyphosine produced a significant response in both recoverable sugar/ton and sugar/A when all tests were combined. Glyphosine did not reduce, significantly, the yield in cane/A as an average of all locations and varieties. However, there was a numerical reduction in cane/A in three of the four varieties studied. Only in L 62-96 was the yield of cane/A not numerically lowered by the glyphosine treatment. It is likely that since L 62-96 is an early maturing variety, its vegetative growth is more nearly complete when glyphosine is applied.

Table 1. Response of four varieties of sugarcane to glyphosine treatment in Louisiana during 1974 and 1975.[1/]

		Average change in [2/3/]					
	No. of	RS/T		TC/A		RS/A	
Variety	tests	(lb)	(%)	(tons)	(%)	(lb)	(%)
CP 48-103	7	18.7*	10.9	-1.4	-4.5	316*	5.9
CP 61-37	17	11.5*	6.4	-0.9	-3.0	189*	3.3
L 62-96	10	14.1*	7.0	0.2	1.2	529*	8.6
NCo 310	7	5.6*	3.1	-0.7	-2.1	109	1.8
Mean		12.4*	6.7	-0.7	-2.2	280*	4.8

1/Glyphosine applied at 3.0 lb a.i./A 5-7 weeks prior to harvest.
2/RS/T - recoverable sugar/ton; TC/A - tons cane/A; RS/A - recoverable sugar/A.
3/Means followed by an asterisk are significantly different at the .05% level of probability.

When varieties were analyzed separately, the variety CP 48-103 responded most to glyphosine treatment in recoverable sugar/ton (Table 1). Because of the reduction in yield of cane/A in treated fields, the 10.9% increase in recoverable sugar/ton converted to a 5.9% increase in recoverable sugar/A. An overall 8.6% increase in recoverable sugar/A was found for L 62-96. The slightly higher increase in recoverable sugar/A over recoverable sugar/ton for L 62-96 was due to the slight gain in yield of tons/A from treated fields. In both CP 61-37 and NCo 310, the gain in recoverable sugar/ton was offset, in part, by a loss of yield of cane/A from treated fields. In both varieties, the gain in recoverable sugar/A was less than 4%.

When tests were analyzed by variety and location, CP 48-103 showed response in recoverable sugar/ton at all seven locations tested, apparently due to the glyphosine treatment (Table 2). However, a portion of the difference between treatments may be due, in part, to the effects of soil heterogeneity since tests at each location were not completely randomized. For varieties CP 61-37 and L 62-96, 16 of the total of 27 tests showed significant increases in recoverable sugar/ton. The variety NCo 310 showed the least response in recoverable sugar/ton. In only one of seven tests was there significant increase in sugar/ton.

Table 2. Number and percentage of individual tests that showed significant response in recoverable sugar/ton and sugar/A during 1974 and 1975.[1/]

		Percent of tests significant for [2/3/]			
	No. of	RS/T		RS/A	
Variety	tests	No.	(%)	No.	(%)
CP 48-103	7	7	(100)	2	(29)
CP 61-37	17	10	(59)	4	(24)
L 62-96	10	6	(60)	2	(20)
NCo 310	7	1	(14)	1	(14)
Mean		24	(59)	9	(22)

1/Glyphosine applied at 3.0 lb a.i./A 5-7 weeks prior to harvest.
2/RS/T - recoverable sugar/ton; RS/A - recoverable sugar/A.
3/Individual tests were found significant at the .05% level of probability.

Generally speaking, plots treated with glyphosine at individual locations did not show response in recoverable sugar/A consistent with the response in recoverable sugar/ton. This inconsistency of response was due primarily to a general reduction in stalk weight of treated cane. However, at individual locations the effect of soil heterogeneity on yield of cane/A may have influenced the response in recoverable sugar/A. Therefore, the combined analyses, by variety, represent a more meaningful presentation of data since the location effect was removed in the combined analysis of variance.

The data for these 41 tests were analyzed for interaction of the three yield criteria studied among locations and geographical areas, methods of harvest (hand vs. machine cut), and varieties. Significant interactions occurred among locations, but not among the three major cane growing regions, i.e., Mississippi River and Bayou Lafourche, the Bayou Teche, and the most northern Bunkie areas. When the 25 hand-cut tests were compared with the 16 machine-cut tests, there was significant interaction. However, at three locations, where hand- and machine-cut samples were directly compared, no significant interactions occurred. Varietal interaction was significant. Response was found independent of location or method of harvest. However, response was related to variety.

In summary, improvement of recoverable sugar/ton was noted at 24 of the 41 locations measured. CP 48-103 responded best and NCo 310, least in recoverable sugar/ton. While the overall increase in recoverable sugar/ton was 6.7%, the increase in recoverable sugar/A was only 4.8%. L 62-96 responded best in recoverable sugar/A and NCo 310, least. The generally low level of response in recoverable sugar/A and the current economic situation precluded any general recommendation of glyphosine use in Louisiana. However, under special circumstances, such as ripening of cane in heavy soils for harvesting early in the season or for reducing the probability of lodging in high tonnage fields, glyphosine may be a useful tool in improving the quality of harvested sugarcane. Also, glyphosine may permit the commercialization of varieties previously unacceptable due to their poor juice quality but which have high yield of cane per unit area of land (13).

ACKNOWLEDGMENTS

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FREEZING, RECOVERY, AND DETERIORATION IN STANDING MILL CANE

J. E. Irvine and B. L. Legendre
U. S. Sugarcane Field Laboratory
Houma, Louisiana

ABSTRACT

Tissue damage followed successive natural freezes with minima of 25 and 24 F on December 19, 1974, and January 9, 1976, respectively. Damage was observed immediately after thawing and 10 or more days later. Damage varied between varieties, and that observed just after thawing was judged more extensive that that observed later. This was noted after both freezes and is the first evidence for recovery from freeze damage in sugarcane. Two variety tests, one with an intact canopy and one in which the canopy had been opened before the freeze, were sampled. Deterioration was less in the test with the intact canopy. Varieties NCo 310 and CP 65-357 were superior in keeping quality. In the open canopy test, varieties CP 48-103 and CP 65-357 were superior and CP 52-68 and CP 61-37 were inferior in keeping quality. Deterioration in standing cane was typical. Increases were noted in dextran soluble polysaccharides and titratable acidity, and decreases were observed in starch, sucrose and purity.

A NEW SUGARCANE FIELD BURNER

Chester Fry and Norman Rozeff
Rio Grande Valley Sugar Growers, Inc.
Santa Rosa, Texas

ABSTRACT

A burner assembly to aid in the ignition of cane field fires is described. Using this device, trash percentages in harvested cane have been reduced by over 2%.

INTRODUCTION

Field trash is costly to both agricultural and milling operations. Poorly burned fields slow harvesting operations by reducing the cutting rate, obscuring the operators view, causing frequent stopping of harvesters to clean trash from chains and conveyors, and increasing the hazards of fire on the machines.

Transportation operations are most costly with trashy cane since bin densities are reduced.

After harvest, the grower has to contend with trash removal by additional burning when legally permitted by the Texas Air Control Board, or by physically raking or incorporating the remaining trash.

At the factory, trash reduces milling extraction, drops purities, and increases the fiber load and pol percent bagasse.

In the Rio Grande Valley, approximately 25% of the cane has received Paraquat desiccation prior to burning and harvest. Usually, after January 1, a freeze has occurred which dries the leaves naturally, thereby eliminating the need for Paraquat.

In the first half of the crop, scheduling and operational factors, plus field blocks adjacent to orchards or other crops where drift hazards exist, preclude desiccation. Approximately 8000 acres are burned without prior treatment, that is, as green cane.

A total of 990 fields in the co-op vary in size from 3 to 149 acres each. Often, irrigation pans break up field blocks into numerous modules where peripheral borders may add up to nearly 3 miles in a 52-acre block.

Previously, fires were initiated by crewman carrying pressurized benzene paraburners. Not only were these men required to rapidly walk long distances, but they were exposed to burn hazards since backburning leeward edges is required by the burn order of the Texas Air Control Board.

When burning within the order limits of 5 to 20 knots wind and up to 30 knots for some variance zones, it was often noted that strong winds tended to snuff out the flames as they were initiated by the paraburners. Not enough fuel was being deposited on the leaf trash. Fires were often erratic and burns poor.

METHODS AND MATERIALS

Borrowing the idea from other cane growing areas, truck-mounted burner units were assembled and perfected after experimentation. The schematic diagram and parts list (Fig. 1) describe the equipment presently employed.

The diesel fuel which is used as the ignition material is carried in a 110 gal tank installed behind the cab of the truck.

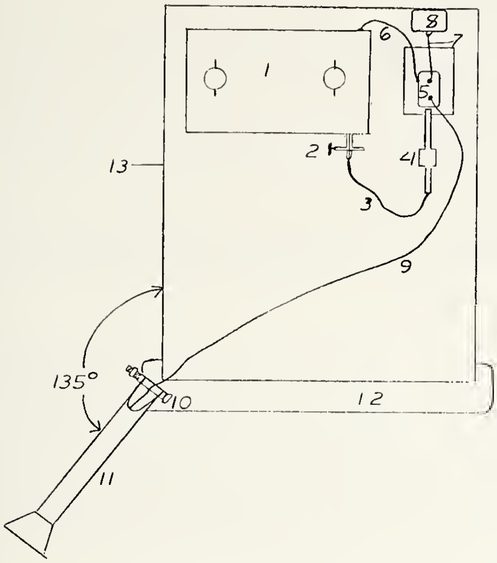
A heavy duty forklift battery has been installed to augment power to the extended duty pump. This is because the pump draws 130 amps, while the truck alternator normally provides only 63-72 amps.

The unit is mounted on a 3/4-ton pickup truck. While going from field to field, or when not in use, the torch is mounted on a transportation bracket on the side of the box. Prior to use, it is assembled on another bracket attached to the mounting bumper in the rear of the truck.

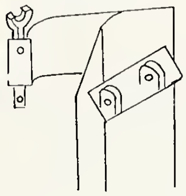
The field checker presses the pump start button, thereby saturating the asbestos wick with fuel. He then stops the pump and proceeds to light the wick. He is then ready to burn. The pickup truck drives at 5-7 miles per hour around the field, staying from 3-7 feet from the cane edge. Pressing the pump starter sends out the flame.

Upon completion of the burn, the ignition switch is shut, the torch is unbolted from its bracket, and the wick extinguished by pressing the funnel into the ground, thereby cutting off air to the flame. Care is taken in not touching hot parts of the torch.

SCHEMATIC OF BURNER SETUP



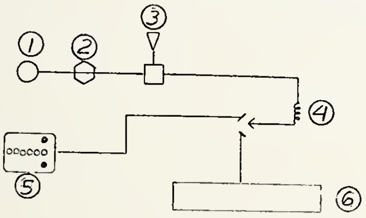
TORCH SUPPORT BRACKET ON BUMPER



1. Reserve Tank (110 Gallon Diesel Fuel Capacity)
2. 1/4" Gate Valve
3. Feeder Hose (3/8" Hydraulic Hose)
4. Fuel Filter (Included With Pump)
5. Monarch Extended Duty Pump (Model 549)
6. Ground Cable (3/8" Battery Ground)
7. Hot Wire (3/8" Battery Cable With Quick Coupler)
8. Electrical Hook Up (Quick Coupler Attachment With Solenoid)
9. Discharge Hose (3/8" Hydraulic Hose)
10. Bumper Mount (U-Shaped Bracket With Holes To Fit Bolt)
11. Torch
12. Truck Mounting Bumper
13. Truck Box

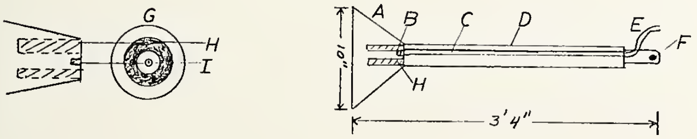
Figure 1. Schematic of burner setup.

ELECTRICAL SYSTEM



1. Truck Ignition Switch
2. Fuse
3. Burner Push-Pull ON-OFF Switch
4. Continuous Duty Solenoid
   (Pulls 1/2 AMP)
5. Forklift Battery 12 Volts
   395 AMP Hr. Reserve
6. Monarch Pump (Model 549-Includes
   Fuel Filter & Solenoid Above)

TORCH



A. Heat Shield Funnel
B. Spray Nozzle With #8 Spray Tip And #31 Spinner
C. 3/8" Pipe
D. 2" Pipe
E. Connecting Hose-3/8" Hydraulic Hose
F. Bracket ⊏⊐ For Quick Setup And-Removal
G. Heat Shield-Light Metal
H. Asbestos Wick Packed In Perforated Pipes (Inside Pipe Is
   2" Diameter, Outside Pipe 4" Diameter, Both 4" Long)
I. Spray Nozzle

Figure 2. Electrical system.

RESULTS AND DISCUSSION

The burner pump puts out 1.7 gal per minute. As an example, an undivided 20-acre block would have a periphery of .7 mile. In the 9 minutes required to circle the block, 15.3 gal of fuel would be used.

The flame produced by the torch is of sufficient dispersion and volume to ignite the trash without being snuffed out, even in winds of over 20 knots. It does a better job of igniting greener fields and those that are slightly moist.

The initial heat is intense enough to generate a sweeping burn front which carries rapidly through the field. By circling the field rapidly, the field checker starts a ring of fire which creates its own updraft. The rising air feeds the fire and towards the end of the burn a fire storm usually develops.

Here are some comparative trash figures for the 1975-76 campaign:

DATE	METHOD	MILL TRASH %
10/6-22/75	Non-Paraquat, paraburner	18.58
10/23-11/13/75	50% of field Paraquated, paraburner	13.84
11/14/75-1/14/75	50% of field Paraquated, new torch	11.79
1/15-3/9/76	After freeze took effect, new torch	8.64

(As a sidelight, one may extrapolate from the first 2 figures what the value of Paraquat is in trash reduction. It calculates to a 9.1% trash figure for Paraquated fields only, or 9.48% less than the non-Paraquated cane. Using the rule of thumb formula that 1% trash costs .89 lb sugar per ton of cane, then 9.48% would be worth 8.44 lb sugar/ton cane. With the Valley average at 40 tons cane/acre, and with 15¢ per pound sugar, the recovery is 337.6 lb or $50.64. Material plus aerial application costs for desiccation ran $7.48 an acre in 1975).

The use of manual labor in burning has been drastically reduced. It is now solely confined to blocks where accessibility by the pickup is impossible. The dangers inherent with hand burning have been minimized. The burning duration has been shortened. More effective updrafts, which punch the smoke and cinders up to the 3000' level, have reduced the nuisance factor for adjacent urban areas.

VARIETAL DIFFERENCES IN SUGAR LOSSES WITH TWO HARVESTING METHODS

B. R. Eiland, J. D. Miller, and G. J. Gascho
USDA, ARS
Belle Glade, Florida
and
USDA, ARS
Canal Point, Florida
and
Florida Agricultural Experiment Station
Belle Glade, Florida

ABSTRACT

Four sugarcane varieties were studied using the whole-stalk conventional harvesting method and a chopper harvester to determine the rate of sugar loss after harvest. Sugar losses were determined over a four-day interval at three sampling dates. Samples were milled at approximately one, two, and five days after harvesting. Sugar loss rates in the chopped samples ranged from 2.7% for CP 68-1067 to 6.5% per day for CP 63-306. The highest sugar loss occurred in the chopped samples of CP 65-357, which lost about 30.3 kg of sugar per ton over the four-day interval. Sucrose, purity, sugar per ton, and pH all decreased in the chopped samples as the interval after harvest increased. There was little change in these traits for the whole-stalk samples over the entire sampling period.

AN INVESTIGATION OF MACHINE-CUT SUGARCANE LOSSES

Norman Rozeff and John Tucker
Rio Grande Valley Sugar Growers, Inc.
Santa Rosa, Texas

ABSTRACT

In a test at the Rio Grande Valley Sugar Growers, cane, juice, and sugar from Massey-Ferguson 201-harvested plots were compared with hand-cut, hand-topped grab-loaded cane. In tonnage averaging 44 TCA, the machine left 1.6% cane as scrap in the field. No statistically significant differences were found in cane delivered, juice quantity produced, or juice quality of machine-cut cane compared to hand-cut cane. An assessment of results indicated that losses attributed to machine harvesters may be more in the realm of management-controlled factors than in inherent machine deficiencies.

INTRODUCTION

It is difficult to find or obtain reliable information on machine-cut cane losses. At the Rio Grande Valley Sugar Growers, a test was designed to determine the extent of juice and cane losses and possible effects on juice quality of Massey-Ferguson machine-cut cane versus hand-cut, hand-topped grab-loaded whole stalk cane.

MATERIAL AND METHODS

At 13.01 acre block of NCo 310, estimated to run 35 net tons cane/acre, was selected as the test site. It had rows 479 feet in length with 5 1/2 feet row spacing. Fourteen 8-row plots were staked out with 3 rows of guard lines between each plot. The plots alternated between machine- and hand-cut plots. Forty five rows were left for crop cane on each side of the test area.

The cane was burned about 14 hr before the cutting commenced. Eight hand cutters were assigned to each .42 acre plot. Four laborers, at each end, began cutting the plots. The cane was windrowed across rows 2-3 and 6-7.

After windrowing, the cane was loaded by a Louisiana type grab-loader directly into the regular 10-ton cane bins. Cane weights for each replication were kept separately.

The hand-cut plots were closely scrapped. The scrap was accumulated for all the hand-cut plots, weighed, and put together with the hand-cut cane for the mill run.

A Massey-Ferguson 201 harvested the seven machine cut plots. In order not to skew the small plot results, the machine broke into the first machine-cut plot row while the accompanying tractor and trailer rode over the guard rows rather than knock down the experimental cane.

The machine-cut rows were also well scrapped. The spilled and attached cane was collectively grouped with the machine-cut cane for the mill run.

The cane, after delivery to the mill, was given a block run. The mill train was gapped before and after each treatment. Juice scale weights were recorded and crusher juice samples taken along with fiber and pol percent bagasse samples.

A mill train grab sample from each treatment was taken for percent trash determinations.

RESULTS AND DISCUSSION

The burn was excellent. The cane was about 2/3 down. About 50% of the tops was almost completely burned off. The remainder was well dehydrated by the fire. No green leaf trash was evident in either of the treatments. The burn was at 4:30 pm on 2/16/76. Handcutting commenced at 7 am 2/17/76. It was completed in 6 hr. Grab loading into 10-ton bins was done from 3 to 7 pm and 7 to 9 am the next morning.

Machine cutting of short cane (7-12" in length) commenced at 7 am 2/18/76, and was completed by 2 pm.

During the harvest period, dry windy conditions prevailed. The high temperature was 90 F; the low for the period was 62 F. No dehydration of cane was noted in either treatment.

Percent trash was 2.8% for the hand-cut cane and 10.7% for the machine-cut.

The grab-loaded cane (exclusive of scrap) averaged 4.94 tons per bin, while the machine cut seed averaged 10.39 tons per bin.

The paired plots gave the following tonnages:

	Hand-cut			Machine-cut		
Plot no.	Actual tons gross weight	Net TCA	Net TCA w/scrap	Actual tons gross weight	Net TCA	Net TCA w/scrap
1	18.59	43.0	46.3	21.78	46.3	47.0
2	18.32	42.4	45.7	22.17	47.1	47.8
3	18.38	42.5	45.8	21.95	46.7	47.0
4	18.20	42.1	45.4	20.74	44.1	44.4
5	16.63	38.5	41.8	19.60	41.7	42.0
6	16.47	38.1	41.4	20.40	43.4	43.7
7	16.96	39.2	42.5	18.85	40.1	40.4
Scrap	9.92			2.30		
Total	133.47			147.79		
Avg. gross	19.07			21.11		
Avg. TCA			44.0			44.8

At the 5% level of probability, there was a statistically significant difference in net TCA cut and delivered by the Massey-Ferguson harvester over hand-cut grab-loaded cane. When the scrap is included for both, there is no longer any significant difference. The amount of cane left behind by the grab-loader was, in this test, significantly higher than that left by the Massey-Ferguson harvester. The cane was very uniform in tonnage throughout the test area.

Four first crusher juice samples from each treatment were taken. The results are:

	Brix	Pol	Purity
Hand-cut	18.70	15.38	82.25
Machine-cut	18.96	15.55	82.01

Using the A.S.C.S. formula (see appendix), the yields were:

Hand-cut:	207.9 lb sugar/ton net cane, or 10.4% yield
Machine-cut:	228.5 lb sugar/ton net cane, or 11.4% yield

On a field basis, this yield would produce:

Hand-cut:	4.58 tons sugar/acre
Machine-cut:	5.11 tons sugar/acre

Bagasse analyses showed:

	Hand-cut	Machine-cut
pol % bagasse	4.66	4.58
Moisture (%)	61.4	60.4

The high moisture was primarily due to the low density of the mat of cane being crushed. This was due to the long stalks, minimum mill roll openings, and to gapping of the mill train between treatments.

Equal maceration water was added to both treatments. The milling time for both was identical at 35 minutes each.

A second series of tests was also run utilizing the Hawaiian Sugar Technologists disintegrator pol-fiber method, 300 g samples were removed from the mill train after the shredder and analyzed.

	Hand-cut	Machine-cut
Ref. sol. sample %	15.85	15.75
Pol % sample	13.14	12.92
Purity	82.91	82.09
Fibre %	14.48	12.25

Using these figures, we obtain:

	Hand-cut	Machine-cut
Tons pol/acre	5.78	5.79

We are unable to offer an explanation for the variation in fiber between the two treatments.

The actual juice obtained from the treatments were:

	No. of juice scales dumped	Tons of juice	Tons of juice per Net tons cane	Tons of juice per Gross tons cane
Hand-cut	18	130.50	1.00	.97
Machine-cut	19	137.50	1.04	.93

In terms of productivity, the Massey-Ferguson operated 6.12 hr, during which it cut 24.1 tons gross cane per hour and actually delivered to the bin 23.8 tons gross cane per hour. This low rate is due to the short rows and proportionately high row-end turnaround time, coupled with careful experiment supervision. The pour rate at which the machine operated was 45 tons/hour.

A hand cutter averaged .477 ton gross cane per hour or 3.8 tons per 8-hour man-day. It is doubtful, however, that our inexperienced cutters could have sustained this rate over a longer period of cutting.

The grab-loader, operated by a relatively inexperienced driver, required 8.5 hr to load the 123.55 tons. This calculates to 14.5 tons/hour, considerably lower than that normally obtained in Louisiana production.

CONCLUSIONS

Conducting a harvest test in a uniform area under ideal conditions we were able to accumulate data on cane and quality losses of machine-cut cane in comparison with that which we started with in the field (as represented by hand-cut long stalks). We established that a well operated, properly maintained machine lost only 1.6% of the gross tonnage in a 44 ton per acre field.

Under very good burn conditions, 10.7% trash was obtained with machine-cut cane against 2.8% for the hand-cut. (Since January 24, the daily factory trash percentages have averaged 8.6 under excellent burn conditions following a freeze.) Without extracting excessive material, 7-10% trash appears to be the minimum obtainable with good burns.

Juice quantity and fiber figures indicated that little, if any, juice was lost in the harvesting and chopping process when coupled with speedy delivery and milling. Additional analyses showed that the machine did not cause a loss in juice quality such as might be expected had there been smashing of cane pieces, incorporation of dirt and extraneous matter, and inclusion of tops and other trash.

This test indicates that machine-cut cane has a very acceptable base level of cane quantity and quality production. Proceeding from this level, other operational factors may combine to reduce tons pol delivered at the loading table. These negative factors may be minimized to some extent by proper management.

Positive controls, such as reduction of trash with desiccation and/or burns conducted with proper weather conditions and technique, reduction in time between burning and harvest, good row configuration conducive to machine harvesting, wide level turnrows, adequate maintenance of equipment, i.e., extractors, toppers, ground blades, choppers, etc., operator training and in-field supervision, which brings quick adaptation and modification in routine as required by field conditions and layout, alert tractor-trailer operators who avoid spillage yet obtain acceptable bin densities, and minimal cane yard storage periods, can reduce the losses greatly.

In short, reported losses may be less attributable to inherent machine functions than to other controllable operational factors.

EXPLANATION OF A.S.C.S. FORMULA

$$\text{CRS,RV} = \frac{\text{NJE x BHE x 2000 x NJS x PR x RVCF}}{\text{(Polarization of Sugar)}\ \frac{\text{Net Sugarcane}}{\text{Gross Sugarcane}}\quad \text{As \%)}}$$

CRS,RV = CWTS, of Sugar, Raw Value Recovered Per
Net Ton of Sugarcane Delivered by Each Producer

NJE = Normal Juice, Percent Gross Sugarcane Ground for the Crop = .71

BHE = Boiling House Efficiency for the Crop = .9525

NJS = Normal Juice Pol

PR = Purity or Retention Factor = $1.4 - \frac{40}{P}$

P = Producer's Normal Juice Purity

RVCF = Raw Value Conversion Factor Determined for the Polarization of Sugar Produced from the Crop Determined in Accordance with Section 101 (h) of the Sugar Act of 1948, As Amended = 1.04812

Polarization of Sugar = .98565

USE OF THE DYNATROL DENSITY ANALYZER IN SUGARCANE JUICE ANALYSIS

F. A. Martin
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

The Dynatrol density analyzer, which employs a vibration principle to measure liquid density, was tested for static determination of raw sugarcane juice density. Results indicate that the instrument can be used for raw juice density determination. The resolution is better than 0.00011 ASG (0.025 brix).

INTRODUCTION

Of the methods available for sugarcane juice density determination, the hydrometer and refractometer are most generally used in Louisiana. The Dynatrol density analyzer employs a vibration principle to measure liquid density. This analyzer has been applied in processing for "in instream" measurements. The research reported herein was undertaken to determine the feasibility of using this density cell in static determinations of raw sugarcane juice density.

MATERIALS AND METHODS

A type CL-10TY Dynatrol Density Cell connected to a type EC-212GA-4 converter was used in this study.[1] The converter was equipped with a 250 hertz crystal which gave it an overall range of 0.75 to 1.25 specific gravity units. The output of the converter was recorded on a Hewlett-Packard model 7127A strip chart recorder with a model 71500A multispan input module. The instrument was adjusted for an apparent specific gravity (SG) range of 1.04003 (10 brix) to 1.08297 (20 brix) using standard sucrose solutions made by weighing the required amount of sucrose and making it to volume in a volumetric flask.

To facilitate sample handling, the density cell was mounted on a 2 1/2 degree incline perpendicular to the U-tube (Fi. 1A). A valve and sample reservoir was installed at the input end of the sample cell, which was on the low side of the incline (Fig. 1A, 1B). Tygon tubing was attached to the discharge end.

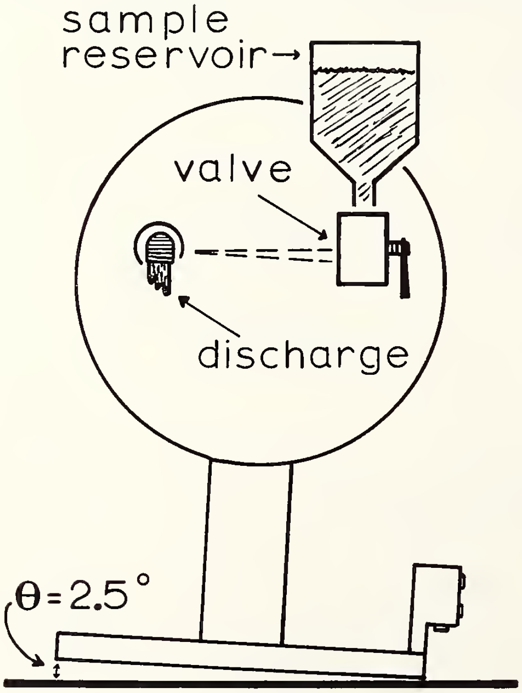


Fig. 1A. Drawing of dynatrol density cell mounted on incline.

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[1] Appreciation is expressed to Mr. J. Simpson, Automation Products, Inc. for use of his dynatrol density analyzer.

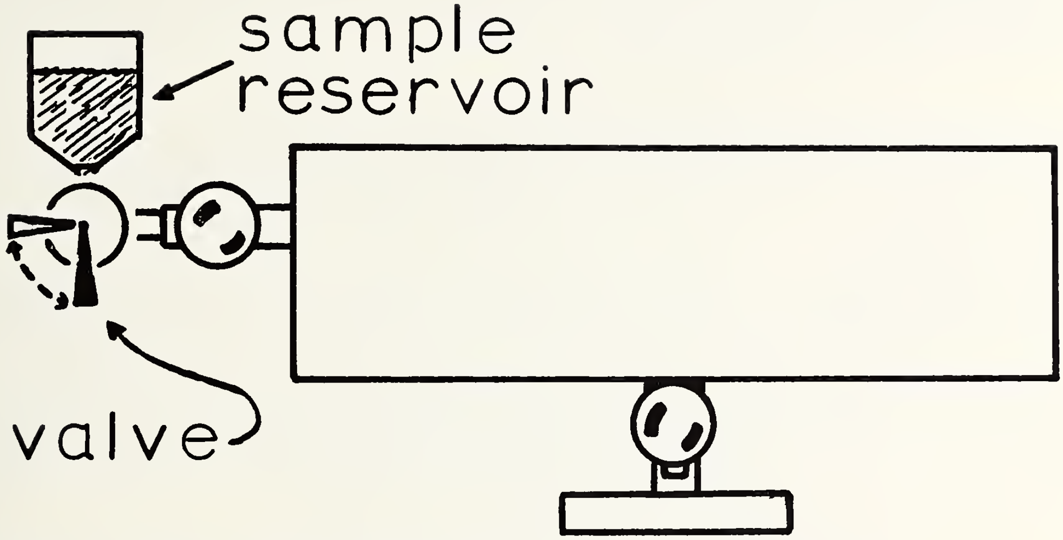


Fig. 1B. Drawing of valve and sample reservoir for use with the density cell.

Juice samples were de-gassed by stirring under vacuum. After pouring the de-gassed sample into the reservoir, the valve was opened to allow the sample to enter the cell. Closing the valve, immediately before the reservoir emptied, trapped a bubble-free sample in the cell. After the ASG was recorded, the valve was opened and the sample vacated the cell by siphon action. The sample was either discarded or retrieved for further analysis.

RESULTS AND DISCUSSION

Results obtained with the Dynatrol density analyzer using standard solutions are shown in Table 1. If the recorder reading is used directly, a 0.05 brix error is obtained in the middle of the range. This is because of a nonlinear relationship between ASG and brix. However, if the ASG is calculated, it is in excellent agreement with the ASG of the standard. The brix then can be calculated from this ASG. Assuming a linear relationship between ASG and brix essentially regenerates the initial recorder reading. However, if a second order relationship is used to calculate brix from ASG, brix between 14 and 22 can be calculated to the nearest hundreth.

The volume needed to flush out previous samples varied with the difference between brix of the two samples. For extremes of 12 to 20 brix, 250 ml of sample was found adequate.

Comparisons of hydrometers with dynatrol measurement on sugarcane juice samples can be seen in Table 2. There is fairly good agreement between the two measurements. The lack of a perfect agreement is probably due to the variation amongst hydrometers (Table 3) and the human error in reading the hydrometers. Agreement between hydrometer and dynatrol was considerably better when only one hydrometer was used (Table 2).

The Dynatrol density analyzer can be used for raw juice density determination. This method gives true density of solution. The resolution is better than 0.00011 ASG (0.025 brix) with the recording system we used. Resolution could be improved with other output device or by direct input into data processing unit. A media temperature compensation is available, which eliminates need for temperature corrections.

Table 1. Results of Dynatrol density analyzer with standard solutions.

Standard solution[1]		Reading	Calculated specific gravity[2]	Calculated brix	
Brix	Specific gravity			Linear[3]	2nd order[4]
10.50	1.04210	10.55	1.04210	10.55	10.48
12.00	1.04837	12.00	--	12.00	11.99
14.00	1.05683	13.95	1.05680	13.96	13.99
16.00	1.06542	15.95	1.06545	15.96	16.00
20.00	1.08297	20.00	--	20.03	20.00
21.00	1.08744	21.05	1.08751	21.07	21.00

[1] The instrument was initially adjusted with the 12.00 and 20.00 standards.

[2] Sp. gr. = $0.0004325x + 1.03972$.

[3] Calculated from Table 22 of Spencer-Meade; Cane Sugar Handbook. Range 10 to 21; brix = $232.00\,(S.G.) - 231.22$.

[4] brix = $\sqrt{13{,}328.75 - 60{,}923.6\,(1.000435 - A.S.G.)} - 115.4852$.

Table 2. Relationship between hydrometer brix and dynatrol brix.

Comparison	y = ax + b	r
random hydrometers vs dynatrol	$y = 1.035x - 0.46$	+0.9896
one hydrometer vs dynatrol	$y = 0.9918x - 0.22$	+0.9983
one hydrometer vs dynatrol (dynatrol set by initial reading of hydrometer)	$y = 1.016x - 0.04$	+0.9953

Table 3. Variation amongst hydrometers commonly used in the sugar laboratory.

	Reading in standard solution	
Hydrometer	12.00*	20.00*
A	11.9	19.8
B	11.8	19.9
C	11.9	20.0
D	12.1	20.1
E	11.9	19.8
F	11.9	19.9
G	12.0	19.8
H	12.0	20.0

*brix of standard solution.

GENERAL ASPECTS OF POLARIMETRY AND ITS APPLICATION IN THE SUGAR INDUSTRY

Manfred F. Nolting
Schmidt and Haensch
Berlin

ABSTRACT

Polarimetry, a method of quantitative chemistry, is limited to fluid matter having optical activity, i.e., transmitting light, linear polarized light, especially. Measurement of optical rotation, a specific property of materials, is an application of polarimetry. Biot's law is the basis for the use of polarimetry in sugar technology. Temperature, concentration, solvent, wavelength and time all influence specific optical rotation in the measurement of dissolved substances and their influences are compared and evaluated.

I have been very pleased indeed to receive an invitation to attend your meeting, which enables me to deliver a short abstract on polarimetry and its application in the field of sugar technology. Of course, polarimetry is a well known field to all of you and many of you will have done polarimetric work with various instruments of different manufacturers. Even so, allow me to recall to your kind attention some basic facts on polarimetry.

Polarimetry is one of the methods of quantitative chemistry. Its application, of course, is limited to matter showing optical activity, that means to those materials which interact with through-passing light and here especially with linear polarized light. The interaction of the molecular electric field distribution and the electrical part of the linear polarized light results in a rotation of the plane of the electric field vector of that light. This rotation is a specific property to those materials because, as you know, the different molecules also have their own specific field distribution, which is connected to the molecular structure. The specific rotation therefore classifies the tested material under known test procedures and with given definitions. The definition for the specific rotation of optically active matter dissolved in an inactive substance is:

$$[\alpha]_{\lambda}^{t} = \frac{100 \cdot \alpha}{l \cdot c} \quad \left[\frac{ml\ (^{\circ})}{dm\ g}\right]$$

Measuring then the degree of that rotation is actually applying polarimetry; however, polarimetry is by far not so simple as just outlined in general.

You have to know more than just the basic facts of polarimetry in order to use this method as a tool in analytical chemistry and especially in that field you are most interested in, in measurement of sugarcane.

As already mentioned, a dissolved optically active material with a concentration of c grams in 100 ml solution in a polarimeter tube of 1 dm length will show a rotation angle of:

$$\alpha = [\alpha]_{\lambda}^{t} \frac{c \cdot l}{100}$$

This equation, known as Biot's law, is the basis for the use of polarimetry in sugar technology.

It determines that you are able to measure the concentration of a dissolved substance with a known specific rotation; however, you will have to consider some specific conditions when measuring. Let me mention now only some of the most important aspects in this connection which are:

Temperature
Concentration
Solvent
Wavelength
Time

All of them can influence your measuring results in polarimetry to quite an extent. If only one of these conditions is changing, the value of the specific optical rotation will also change. Therefore let me discuss these conditions for better general understanding.

The specific optical rotation is changing due to temperature influences on intramolecular forces, molecular association, molecular attraction, etc. For example with a sodium light source:

for sucrose in water solution $[\alpha]^{20} = +66.53$; $c = 26 g$

$$[\alpha]^{t°} = [\alpha]^{20°}\left[1 - 184 \cdot 10^{-6}(t-20) + 63 \cdot 10^{-7}(t-20)^2\right]$$

for quartz $(\alpha)^{20°} = 21.724$ (+ for dextrogyr ; − for levogyr]

$$(\alpha)^{t°} = (\alpha)^{20°}\left[1 + 136.668 \cdot 10^{-6}(t-20) + 1.003 \cdot 10^{-7}(t-20)^2\right]$$

For polarimetric measurements of solutions it is not necessary to apply temperature corrections if the sample is prepared at 20 C ambient temperature and the measurement is effected in a polarimeter at the same 20 C temperature.

However, if sample preparation and sample measurement is effected at a temperature divergent from the standard temperature of 20 C a temperature correction is necessary. How much that will be and when there is need for temperature corrections in practice I shall discuss later.

The next factor to be dealt with is the influence of concentration. For example with a sodium light source:

for sucrose in water solution $[\alpha]_D^{20°} = 66.53 + 870 \cdot 10^{-5}c - 235 \cdot 10^{-6}c^2$

$$(c = 9 \ldots 35 g/100 ml)$$

for invert sugar in water solution $[\alpha]_D^{20°} = -19.7 - 3{,}600 \cdot 10^{-5}c$

There is also a relation between the value of the specific optical rotation and the kind of solvent used, however, this relation is more important in general analytical chemistry than in sugar measurements.

One of the most important factors in polarimetry is the colour dependence of the tested materials. This effect, known as

Optical Rotation Dispersion (O R D),

means that, dependent on the used wavelength of light for polarimetry the value for the specific optical rotation is different for any frequency or, simply said, for any different colour. E.g. quartz, in our field of interest a very important material, has the following values for ORD:

wavelength in nm	specific rotation at 20 C
644,0251	18,02238
589,4400	21,72446
546,2271	25,53531
480,1235	33,67434
435,9562	41,54553
407,8989	48,11211

Nearly exactly the same ORD is shown by a solution of sucrose in water (see Fig. 1). It is because of this fact that for sugar polarimetry quartzwedge compensation polarimeters are still the best known and most recommended type of instrument.

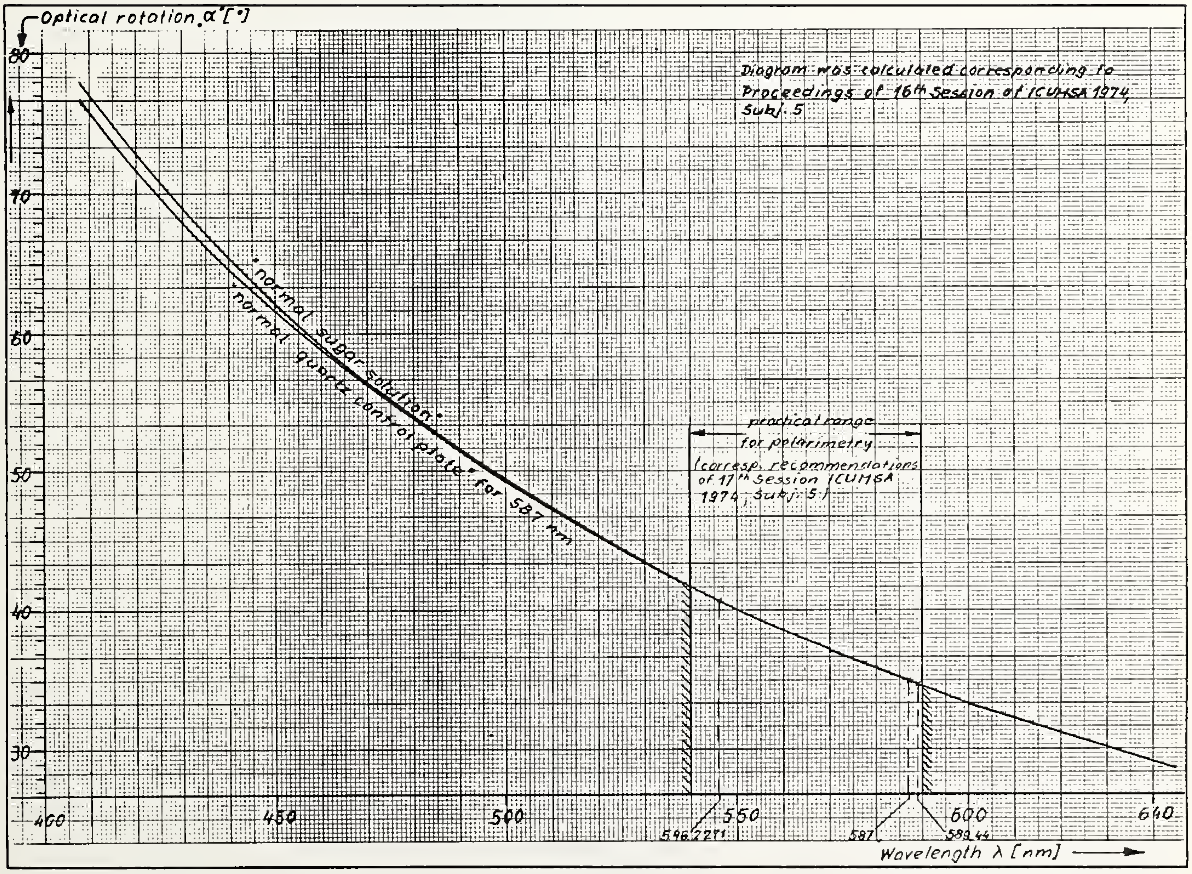


Fig. 1. Optical Rotation Dispersion of a "Normal Quartz Control Plate" for 587 nm and a "Normal Sugar Solution.

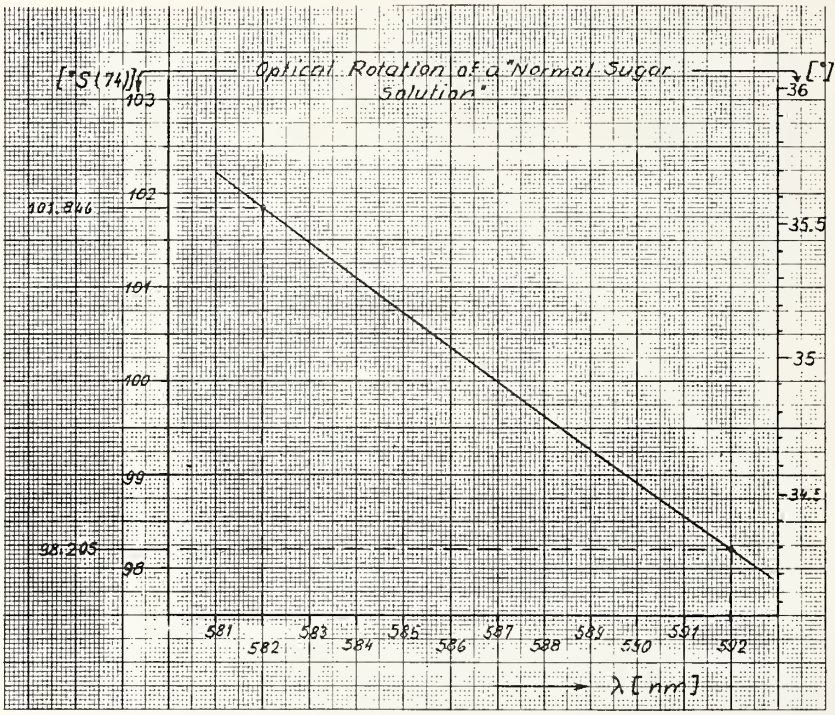


Fig. 2. Optical Rotation of a "Normal Sugar Solution."

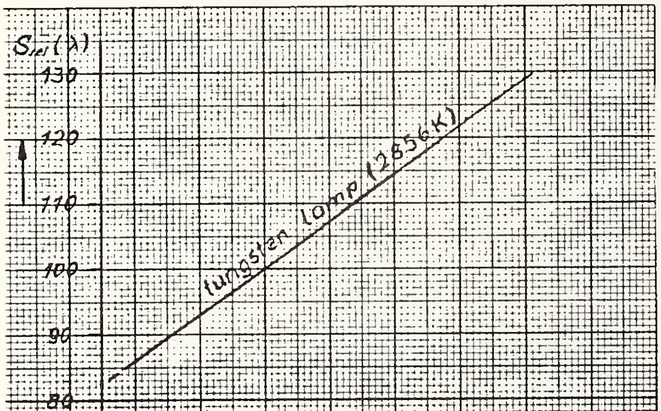


Fig. 3. Rel. Spectral Distribution of Tungsten Lamp Radiance (color temperature 2854 K).

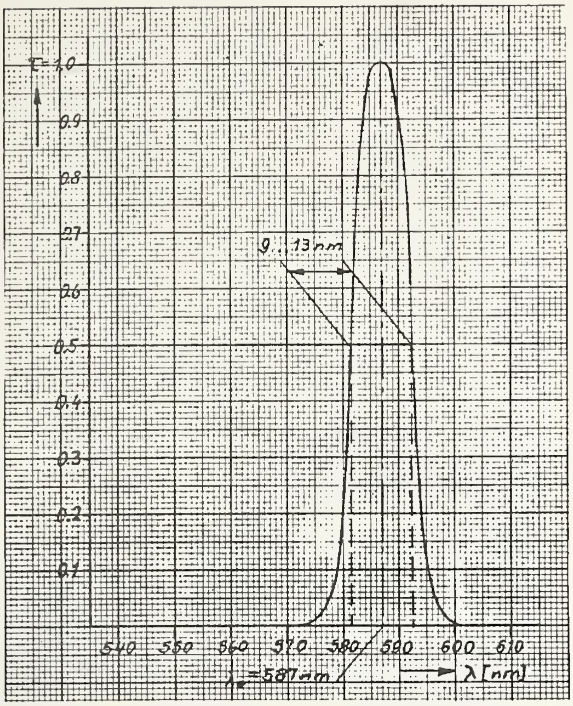


Fig. 4. Spectral Transmission of an Interference Filter (e.g. SCHOTT type DIL).

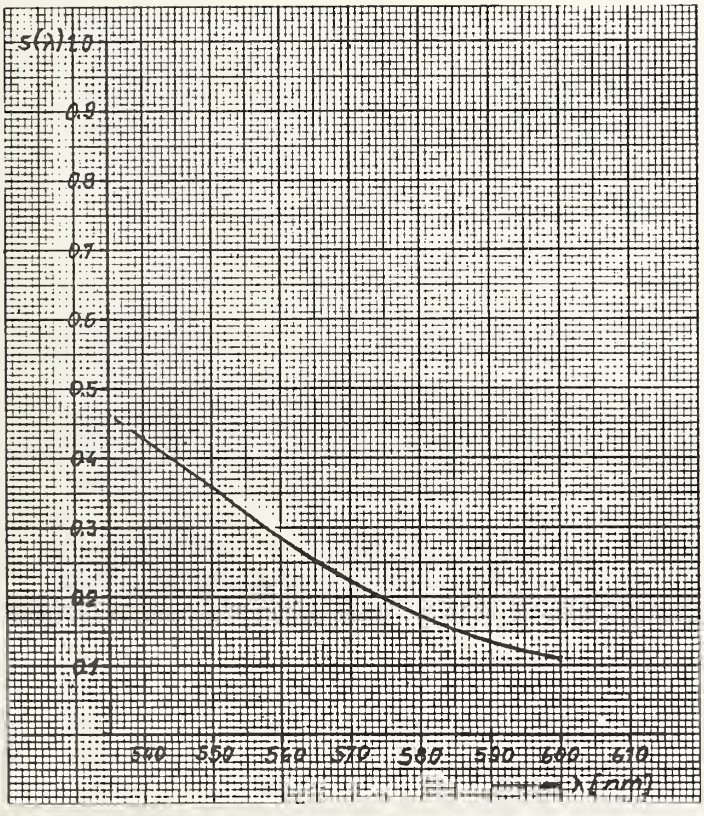
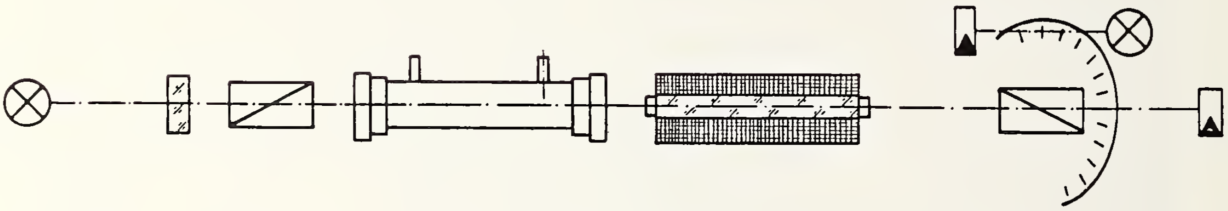
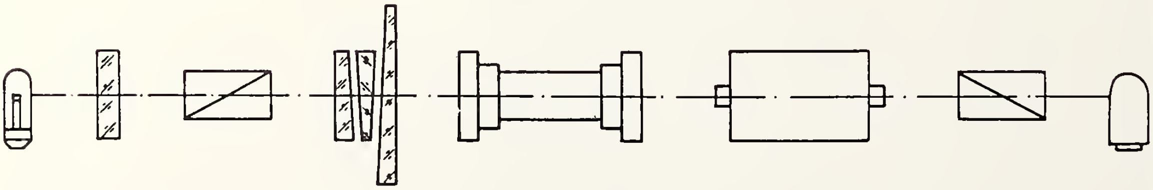


Fig. 5. Rel. Spectral Sensitivity of a Modern Photomultiplier.



SCHEMATIC DIAGRAM OF PHOTOELECTRIC CIRCLE POLARIMETER

Fig. 6. Sensitivity of a Photoelectric Polarimeter.



SCHEMATIC DIAGRAM OF PHOTOELECTRIC QUARTZWEDGE COMPENSATION POLARIMETER (SACCHARIMETER)

Fig. 7. Schematic diagram of photoelectric quartzwedge compensation polarimeter (Saccharimeter).

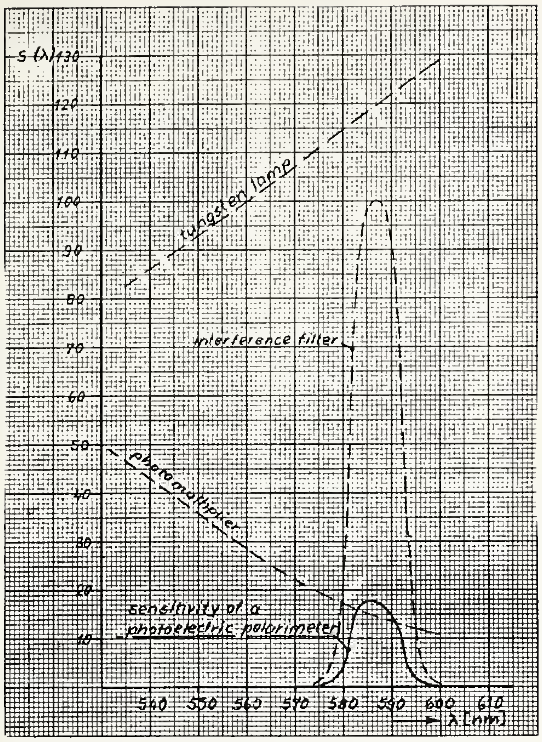


Fig. 8. Schematic diagram of photoelectric circle polarimeter.

The last effect to talk about is the time-dependence of the specific optical rotation, also known as muto-rotation. That effect means that the value of the specific optical rotation for a freshly prepared solution of some kind of material will only be reached after a certain lapse of time, which could be some seconds only, which could be for another material 10 minutes or even more.

Glucose and some other sugar derivatives which are important in sugar technology have a strong muto-rotation, e.g.:

	first value	final value	time to reach final value
Glucose	+ 112,2	+ 52,7	8 h
Lactose	+ 85,0	+ 52,6	10 h
Lyxose	- 72,6	- 13,8	52 m
Xylose	+ 93,6	+ 18,8	2,5 h
Rhamnose	- 8,6	+ 8,2	1 h
Fucose	- 152,6	- 75,9	2,25 h
Mannose	- 17,0	+ 14,2	2,5 h
Cellobiose	+ 14,2	+ 34,6	10 h
Gentiobiose	+ 21,4	+ 8,7	3,5 h

What I have said so far will serve as a summary outline on polarimetry in general.

Let us now discuss the special requirements of polarimetry in the sugar industry in respect of the beforementioned facts in order to establish which type of polarimeter would be the most advisable instrument for measurements in sugar technology.

In the sugar industry the determination of sucrose is one of the most important fields of polarimetry. There are quite a few regulations and recommendations governing this special field of interest which have been issued by the ICUMSA, the ISSCT etc.; however, the basic law for polarimetry, Biot's law, transformed for sucrose determination reads

$$x = \frac{\alpha}{[\alpha]} \cdot \frac{10,000}{c \cdot l} ,$$

where x is the percentage of sucrose in a solution of (1 - x) percent inactive solvent. This allows one to determine sucrose if c and l are fixed by an international standard. Of course, it must be said, that under all conditions the wavelength of the polarized light has to be always exactly the same for all measurements.

The international standard edited by the ICUMSA states that c should be 26 g of purest sucrose weighed with brass weights at 1013 mbar pressure, 20 C and 50% rel. humidity per 100 ml solution and that l should be 200 mm for polarimeter tube.

In addition the temperature for the measurement should be held at 20 C. By doing so the reading of a polarimeter under these conditions will give a direct value for the contents of sucrose in percent or - acc. to the international standard - in degrees of sugar (ISS - International Sugar Scale).

To avoid non-neglectable difficulties in preparation of such a standard solution it has been agreed that to get a standard of high reliability, which is easily available, the use of a quartz plate is permitted. To use a quartz plate fairly suggested itself because the optical rotation dispersion of sucrose and quartz are practically exactly the same within the whole range of visible light. According to the standard measurements of Bates and Jackson and later on the measurements of the German Bureau of Standards (PTB) a quartz plate of 100°S has a rotation value for light of 589.44 nm of $34.626^\circ \pm 0{,}001^\circ$.

The important question now is to calibrate a polarimeter used for sucrose measurements by means of a standard quartz plate. An exact calibration precluding any possible argument is possible only with a quartzwedge compensated instrument. Polarimeters with a rotating analyser or a Faraday compensator will show an error if their light source is not strictly monochromatic. The deviation in the monochromasy should be less than 0.025 nm for calibration purposes if a measuring accuracy of 0.01°S is required.

Another vitally important question in this connection is how accurate the light source of the polarimeter has to be, in other words, what will be the effect if the wavelength of the polarized light is altered. From many paragraphs in the respective bibliography it can be seen that this effect is of tremendous importance to circle polarimeters because if the wavelength of the light source of a circle polarimeter is altered from 589.0 nm to 589.1 nm - only 0.1 nm! - less than half the bandwidth of a good filter used nowadays in modern circle polarimeters - e.g. a DIL-filter has $\lambda_{\tau 50} \approx 10$ nm - this small deviation results in a measuring error of 0.036°S. If a light source with even shorter wavelength is employed the measuring error will increase.

This effect due to the alteration of the wavelength becomes a real disadvantage to a circle polarimeter to be employed in the sugar industry, as it cannot be helped by adjustment or recalibration and - most important - it cannot be discovered during the measuring process. This is a fact which is true even if you use a laser light source but measuring coloured samples, and as all of you know, of course, sugar solutions as a rule are more or less coloured.

The only instrument which does not show this type of measuring error is the quartzwedge compensated polarimeter. To repeat, this is due to the fact that sucrose and quartz have practically the same optical rotation dispersion. It is mainly for this reason that until 1966 only quartzwedge compensated polarimeters were recommended by the ICUMSA and this advantage in favor of this type of instrument still exists and is valid.

Certain paragraphs in the respective bibliography state that for accurate precision polarimetry even the best interference filters are not good enough and it is recommended to use a highly monochromatic light source, by evaluating all colour effects of the tested sample. Due to the mentioned great interdependency of circle polarimeters to wavelength (frequency) one should take into account that by changing lamp, filter, or detector of the circle polarimeter the whole scale will be affected and can only be recalibrated under extreme difficulties, if it will be possible at all. (In principle with monochromatic light only when using a standard quartz plate. Otherwise a standard sugar solution will be required.)

The last point which I would like to mention is the temperature correction. The exact calculation for this effect I have stated already. For practical purposes it is sufficient to use the following figures:

For circle polarimeter: $^\circ S^{20^\circ} = {}^\circ S^t + 0.0002\,{}^\circ S^t (t-20)$

For quartzwedge compensation: $^\circ S^{20} = {}^\circ S^t + 0.0003\,{}^\circ S^t (t-20)$

For a wide range of practical measurements it is in most cases not necessary to apply any correction between 15 C and 25 C. Furthermore, if required, the instrument can be calibrated for a higher temperature - for tropical countries e.g. to 27.5 C - or to use a polarimeter tube whose length is calibrated for this temperature.

In view of the fact that airconditioned laboratories become more and more common in sugar factories, and taking into account the now available modern facilities of accessories and instrumentation technology as well as sample preparation, for most of the common measurements the use of a polarimeter tube with water jacket is convenient.

I very much hope that the paper which I was allowed to read to you and the diagrams shown were of interest to you.

(Abstract from "Report of the Proceedings of 16th Session of ICUMSA 1974.")

Subj. 5: 100°S - Point of the Sugar Scale

Recommendations

The following recommendations were finally adopted.

1. The normal sugar solution is defined as 26.0160 g of pure sucrose weighed in vacuo and dissolved in pure water at 20 C to 100 cm^3. This corresponds to a concentration of 26 g of sucrose weighed with brass weights in air under normal conditions (1013 mbar pressure, 20 C, 50% relative humidity) in 100 cm^3 of solution at 20 C. (Officially adopted at the 13th session, 1962.)

2. The basis of the 100°S point of the International Sugar Scale is the optical rotation of the normal sugar solution, as defined in Recommendation 1, at the wavelength of the green line of the mercury isotope ^{198}Hg (λ= 546.2271 nm), 20 C and 200 mm tube length. (Officially adopted at the 14th session, 1966.)

3. The rotation value for the 100°S point under the standard conditions specified in Recommendations 1 and 2 is tentatively accepted as:

$$\alpha^{20.00\,°C}_{546.2271\,nm} = 40.777° \pm 0.001°$$

(Tentatively adopted at the 16th session, 1974.)

4. For fixing the 100°S point at other wavelengths, equation (1) of the 1966 Report (Proc. 14th Session ICUMSA, 17) for the rotatory dispersion is valid. Until further notice the range of wavelengths is limited for practical polarimetry to 540 nm to 590 nm. (Officially adopted at the 15th session, 1970.) The mean effective wavelength of spectrally filtered yellow sodium light is adopted as λ = 589.4400 nm. (Officially adopted at the 15th session, 1970.)
At this wavelength, according to Recommendations 3 and 4, the 100°S point will be

$$\alpha^{20.00\,°C}_{589.44\,nm} = 34.626° \pm 0.001°$$

(Tentatively adopted at the 16th session, 1974.)

6. The sugar scale, corresponding to the re-definition in Recommendations 3 and 5, is called "International Sugar Scale 1974" and saccharimeters, as well as standards calibrated according to this, are to be characterized by °S (74). (Tentatively adopted at the 16th session, 1974.)

8. Quartz control plates used to check saccharimeters should fulfill the conditions adopted under Subject 6. (Officially adopted at the 14th session, 1966.)

9. Quartz control plates have the sugar value of 100.000°S (74) at a given wavelength if their rotation is equal to the values given in Recommendations 3 and 4 for that particular wavelength. (Tentatively adopted at the 16th session, 1974.)

10. A plate which shows the same optical rotation as the normal sugar solution under the standard conditions defined in Recommendation 2 is called "normal quartz control plate." (Officially adopted at the 14th session, 1966.)+

+Normal quartz plates which have the same rotation as the normal sugar solution of Recommendation 2, Subject 5, 15th Session 1970 will have a slightly smaller rotation than those corresponding to Recommendation 2, Subject 5, 16th Session 1974. To avoid confusion it is recommended that the two types of plates be described as "Normal quartz control plate 100°S" and "Normal quartz control plate 100°S (74)".

11. Quartz control plates of the sugar value of 100.000°S (74) for saccharimeters equipped with quartz wedge compensation with an effective wavelength of 587.000 nm have the following rotation values:

$$\alpha^{20\,^{\circ}\mathrm{C}}_{546.2271\,\mathrm{nm}} = 40.764^{\circ} \pm 0.001^{\circ}$$

$$\alpha^{20\,^{\circ}\mathrm{C}}_{589.4400\,\mathrm{nm}} = 34.629^{\circ} \pm 0.001^{\circ}$$

(Tentatively adopted at the 16th session, 1974.)

14. Saccharimeter scales should be linearly divided.
(Officially adopted at the 14th session, 1966.)

THE MINI YIELD TEST FOR SUGARCANE RESEARCH

G. T. A. Benda
U. S. Sugarcane Field Laboratory
Houma, Louisiana

ABSTRACT

Sugarcane yield is tested either under greenhouse or under field-plot conditions. The precise determination of yield in the greenhouse is limited by the growth of the cane. The heavy yield from field plots requires mass handling of cane, usually both in the planting and harvest operation. Over the past few years, a mini yield test has been developed at Houma for particular problems not well served by the available alternatives. In this test, young cane is transplanted in the spring from greenhouse to field and hand-harvested in the fall; a plot consists of a single site of planting (one plant only or a cluster of a few plants) on a standard six-foot row, and the plots of different treatments are arranged as Latin Square (6 x 6) or randomized blocks with 6 to 10 replications. Applications (and special needs) served by the mini yield test include: a) reduction in yield as a function of disease, i.e., maximum utilization of limited plant material; b) reduction in yield as a function of distance between plants (experimental variation in gap size by precision planting); and c) competition among shoots at one site, i.e., cluster planting with variable number of plants per site and precise distance between sites.

MICRONUTRIENT STUDIES WITH SUGARCANE IN LOUISIANA

Laron E. Golden
Agronomy Department
Louisiana Agricultural Experiment Station

ABSTRACT

Yields from 8 field tests and leaf blade data from 6 of the tests were obtained at locations where varied rates and combinations of the micronutrients Fe, Mn, Zn, Cu, B, and Mo were applied to sugarcane. Leaf blade and topsoil pH data were obtained from 31 additional locations. Correlations were determined among concentrations of the micronutrients and Al, Sr, and Ba in leaf blades and topsoil pH. Application of the micronutrients to sugarcane resulted in no significant effect on cane and sugar yields or on micronutrient contents of leaf blades. Generally, the Fe, Mn, B, and Mo contents of leaf blades were much higher, and Zn and Cu contents were equal to or higher than critically low levels reported by other workers. Topsoil pH was significantly correlated only with leaf blade Mn (r = -0.685). This negative relationship suggests some possibility of Mn toxicity in sugarcane grown on soils of very low pH. Since leaf blade Al was not significantly correlated with topsoil pH, and work by others in Louisiana indicates an absence or very low amount of measurable exchangeable Al in soils from the sugarcane producing area, it was concluded that Al toxicity probably does not occur in Louisiana sugarcane. Several significant correlations were found among the micronutrient contents of leaf blades, but they apparently were relatively unimportant due to the absence of yield and leaf blade response to application of micronutrients. Significant correlations among micronutrient contents and Al, Sr, and Ba contents of leaf blades apparently did not influence the general nutrition of sugarcane.

INTRODUCTION

In 1940, relatively extensive soil fertility studies were begun in the sugarcane producing area of Louisiana (15). Yield data from 8 field tests conducted with iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), and molybdenum (Mo) since 1948, by personnel of the Louisiana Agricultural Experiment Station and the U. S. Department of Agriculture, showed no beneficial effect from application of these micronutrients (3, 5, 6, 14). However, in one test a significant decrease in cane yield was obtained due to Fe, Mn, Zn, and Cu applied together as a mixture. The rate of each element in the mixture was 1.2 lb/A (3).

Gascho and Taha (8) reported that basic applications of Cu and Zn are necessary before planting previously uncropped land to sugarcane in the Florida Everglades. Andreis (2) found low amounts of Fe, Mn, Zn, Cu, and B removed by millable cane in Florida and noted that most soils have received high rates of Mn, Zn, and Cu during many years of cropping to sugarcane and generally do not need additional amounts of micronutrients except possibly when the soil pH is above 6.5.

Evans (7) reported critical content or concentration of micronutrients in sugarcane leaf lamina and Juang (12) reported critical concentration and range without deficiency symptoms in sugarcane leaf blades as follows:

Micronutrient	Critical content or concentration, ppm		Range without deficiency symptoms, ppm
	Evans	Juang	
Fe	5	10[1]	20 - 600
Mn	20	10[1]	20 - 400
Zn	15	15	20 - 100
Cu	4	5	5 - 100
B	1	1	2 - 30
Mo	.08	.05	.05 - 4

[1] Varies with Fe/Mn ratio. Critical level can be below 10 ppm if Fe/Mn ratio is above 1.

Abdol (1) obtained correlation data from soil pH and Fe, Mn, Zn, and Cu contents of leaf blades in plant and first stubble cane tests with 4 sugarcane varieties grown on soils which varied from Baldwin silt loam to Iberia clay. Soil pH was negatively correlated with leaf blade Zn in plant cane (r = -0.601) and was positively correlated with leaf blade Fe in stubble cane (r = 0.470). Leaf blade Fe was significantly correlated with leaf blade Cu in plant cane (r = 0.517) and with leaf blade Zn in stubble cane (r = 0.587). No other significant correlations were found among the variables.

Davidson (4) reported that yield increases in sugarcane which occurred as a result of application of liming materials and associated increases in soil pH may have been due in part to better nitrogen (N) nutrition of sugarcane. He did not refer to possible relationships between soil pH and other factors which may have influenced sugarcane production in the study. More recent tests with liming materials and with general nutrition of sugarcane (9, 10, 11) showed yield increases due to liming, no consistent effect of liming on leaf blade N and phosphorus (P) contents, a marked decrease in leaf blade Mn content due to liming, and no apparent need for additions of Ca and Mg as nutrient elements for sugarcane in Louisiana.

The primary purpose of this study was to determine the effect of field application of the micronutrients, Fe, Mn, Zn, Cu, B, and Mo on sugarcane yield and on uptake of the micronutrients as indicated by leaf blade analysis. A secondary purpose was to determine the relationship among the micronutrient and aluminum (Al), strontium (Sr), and barium (Ba) contents of leaf blades and soil pH.

MATERIALS AND METHODS

Eight field experiments were conducted with micronutrients applied to sugarcane. Locations of the tests and additional pertinent information are shown in Table 1. Individual plots were approximately 0.1 acre in size and the number of replicates varied from 6 to 8. Leaf blade samples were obtained from all treatments in six of the tests.

Table 1. Soil types and locations of field experiments and rates of micronutrients applied to sugarcane.

						Micronutrients applied[1]	
Exp. no.	Soil type	Plantation	Year	Variety	Age of cane	As mixture or individually	Element amount (lb/A)
1	Baldwin sicl	O'Neil	1966	CP 52-68	Plant	Mixture	Fe,1.5; Mn,1.0; Zn,1.0; Cu,1.0; B, 0.1; Mo,0.1
2	Baldwin sicl	O'Neil	1967	CP 52-68	1st St	Mixture	Fe,1.5; Mn,1.0; Zn,1.0; Cu,1.0; B, 0.1; Mo,0.1
3	Jeanerette sil	Simonaud	1968	NCo 310	1st St	Mixture	Mn,0.7; Zn,1.5; Cu,0.7; B, 0.7; Mo,0.1
4	Baldwin sil	Lamaire	1969	NCo 310	1st St	Ind	Zn,1.7; Cu,0.6; B, 1.0
5	Baldwin sicl	Sterling	1969	CP 52-68	1st St	Ind	Zn,1.7
6	Commerce sil	Evan Hall	1970	CP 48-103	1st St	Ind	Zn,3.4
7	Iberia c	Murphy	1972	CP 48-103	2d St	Ind	Zn,1.0; Cu,0.8
8	Patoutville sil	Roane	1973	L 62-96	Plant	Ind	Zn,1.0; Cu,0.1

[1] In Experiments 7 and 8, applications were applied to cane foliage in liquid form. Other applications were made in the off-bar furrow. All applications were made in the spring.

Thirty-one leaf blade and 31 topsoil samples were obtained from field experiments which were established primarily to study variables other than micronutrients. In addition to analyses for Fe, Mn, Zn, Cu, B, and Mo, the leaf samples were analyzed for Al, Sr, and Ba contents.

The leaf blade samples were obtained from the first leaf below the top visible dewlap when the sugarcane was 3 to 3 1/2 months old.

Analyses of the leaf samples were made by the Ohio Research and Development Laboratory and the Georgia Cooperative Extension Service. Soil pH was determined by use of a Beckman Zeromatic pH meter.

RESULTS AND DISCUSSION

It may be noted in Table 2 that application of mixtures of micronutrients and application of Zn, Cu, and B as individual treatments resulted in no statistically significant effect on cane or sugar yield.

Table 2. Yields of sugarcane and sugar as related to micronutrient treatment.

Exp. no.	Micronutrient[1] treatment	Cane yield	Normal juice			Sugar yield
			Brix	Sucrose	Purity	
		tons/A	%	%	%	lb/A
1	Check	26.22	15.18	11.94	78.66	4269
	Mixture	26.44	15.15	11.86	78.28	4270
	LSD .05	NS				NS
2	Check	34.22	16.77	12.86	76.68	6195
	Mixture	33.56	17.04	13.09	76.82	6220
	LSD .05	NS				NS
3	Check	26.97	16.49	13.01	78.90	4919
	Mixture	27.63	16.77	13.43	80.01	5250
	LSD .05	NS				NS
4	Check	22.08	17.29	13.31	76.98	4147
	Zn	22.67	16.36	12.41	75.86	3904
	Cu	22.00	16.77	13.04	77.76	4028
	B	22.55	16.91	13.07	77.29	4140
	LSD .05	NS				NS
5	Check	22.08	18.32	14.93	81.50	4765
	Zn	21.73	18.20	14.62	80.33	4572
	LSD .05	NS				NS
6	Check	36.41	16.58	13.75	82.93	7140
	Zn	33.81	16.43	13.65	83.08	6569
	LSD .05	NS				NS
7	Check	25.33	16.79	13.64	81.24	4911
	Zn	25.83	16.77	13.65	81.40	5011
	Cu	26.50	16.60	13.39	80.66	5022
	LSD .05	NS				NS
8	Check	36.15	15.26	12.86	84.27	6511
	Zn	36.62	15.20	12.82	84.34	6570
	Cu	36.06	14.95	12.26	82.01	6123
	LSD .05	NS				NS

[1] Rates of micronutrients and composition of mixtures are shown in Table 1.

Leaf blade and soil pH data from field tests established primarily to study variables other than micronutrients are shown in Table 4. The micronutrient contents of leaf blades were of the same order of magnitude as those reported in Table 3 and were related to critical contents (7, 12) approximately as those shown in Table 3.

Correlation coefficients (r) among all variables reported in Table 4 were determined and those which were statistically significant are shown in Table 5.

The negative association between soil pH and leaf blade Mn noted in Table 5 (r = -0.685) indicates a possibility that toxic levels of Mn may occur in sugarcane grown in soils of very low pH.

It was interesting to note that soil pH and Al content of leaf blades were not statistically correlated. Recent work in Louisiana (13) indicated a very low probability that Al toxicity is a problem in production of crops in the sugarcane producing area of Louisiana due to the absence or very low amount of measurable exchangeable Al in soils cropped to sugarcane.

Although several significant correlations were found among micronutrient contents of leaf blades (Table 5), they were considered relatively unimportant since yield and leaf blade responses to application of the micronutrients were not obtained. Correlations among micronutrient contents and Al, Sr, and Ba contents of leaf blades did not appear to influence nutrition of the sugarcane.

Table 3. Micronutrient contents of sugarcane leaf blades as related to micronutrient treatment.

Exp. no.	Micronutrient[1] treatment	Micronutrient content of leaf blades					
		Fe	Mn	Zn	Cu	B	Mo
		ppm					
1	Check	55	150	25	19	6	3.2
	Mixture	54	152	24	17	7	2.8
2	Check	56	175	24	16	6	2.6
	Mixture	55	178	28	16	7	2.8
4	Check	60	152	24	4	4	-
	Zn	68	136	24	6	4	-
	Cu	48	130	20	4	5	-
	B	68	154	20	4	4	-
5	Check	40	32	18	16	4	-
	Zn	50	26	20	12	4	-
6	Check	84	128	23	12	5	2.0
	Zn	78	110	24	13	6	2.3
7	Check	63	104	18	9	5	2.5
	Zn	60	122	20	9	6	2.6
	Cu	61	113	18	8	4	1.9

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[1] Rates of micronutrients and composition of mixtures are shown in Table 1.

Table 4. Micronutrients and selected other elements in sugarcane leaf blades and their relationship to soil pH.

Soil type	Elemental content of leaf blades									Soil pH
	Micronutrients						Other elements			
	Fe	Mn	Zn	Cu	B	Mo	Al	Sr	Ba	
Crevasse sil	63	14	29	21	4	2.0	30	4	14	7.6
Commerce sil	67	106	28	8	8	2.3	24	15	46	5.8
Mhoon sil	76	66	23	11	6	1.8	26	5	25	6.7
Mhoon sil	78	40	24	12	6	1.9	26	7	23	6.6
Mhoon sil	72	48	24	11	5	1.7	22	6	24	6.4
Mhoon sil	72	49	25	13	5	1.6	22	6	26	6.5
Mhoon sil	84	128	23	12	5	2.0	22	6	12	6.5
Mhoon sicl	62	73	20	7	7	1.8	26	7	14	6.2
Mhoon sicl	57	17	19	7	8	2.1	28	5	4	6.1
Mhoon sicl	62	45	19	8	5	2.2	31	8	11	5.8
Mhoon sicl	74	57	20	13	6	1.5	16	6	18	5.6
Sharkey c	68	41	21	12	6	1.8	18	5	15	6.8
Sharkey c	66	39	21	13	5	1.4	15	6	13	6.5
Loring sil	107	213	21	12	5	2.4	45	10	24	4.9
Loring sil	120	235	33	29	7	1.9	49	7	18	5.1
Cypremort sil	65	46	24	9	4	3.2	39	9	12	6.1
Cypremort sil	65	29	22	10	3	3.0	39	9	7	6.2
Cypremort sil	66	25	23	14	4	3.0	40	8	5	6.6
Cypremort sil	66	29	22	10	4	2.8	40	12	13	6.3
Jeanerette sil	66	190	25	9	4	3.0	44	11	50	5.4
Jeanerette sil	59	88	21	9	3	3.1	39	12	30	6.8
Jeanerette sil	64	189	21	8	5	1.6	13	6	45	5.4
Jeanerette sil	72	115	21	9	5	1.6	19	5	31	6.8
Baldwin sicl	80	107	24	8	6	2.4	53	22	35	6.0
Baldwin sicl	57	83	28	11	5	2.5	30	13	21	5.6
Baldwin sicl	60	105	22	9	7	1.9	13	12	27	5.7
Baldwin sicl	58	133	38	15	5	2.8	42	14	18	4.9
Baldwin sicl	63	108	37	12	5	2.6	46	12	22	5.6
Baldwin sicl	42	99	21	9	5	1.5	12	5	14	5.2
Baldwin sicl	56	98	25	11	6	1.4	13	6	17	5.9
Iberia c	64	135	19	9	5	2.0	16	5	7	5.5

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[1] Plant cane tests. The other tests were with stubble cane.

Table 5. Correlation coefficients[1] and linear regression equations for the relationships among elemental contents of sugarcane leaf blades and soil pH.

Factors correlated X	Factors correlated Y	Correlation coefficients	Linear regression equations
Fe	Mn	0.494	Y = 1.99X - 47.8
Fe	Cu	0.569	Y = 0.169X - 0.307
Fe	Al	0.391	Y = 0.328X + 6.39
Mn	Ba	0.507	Y = 0.101X + 11.7
Zn	Cu	0.549	Y = 0.494X - 0.517
Zn	Al	0.457	Y = 1.16X + 1.11
Zn	Sr	0.356	Y = 0.296X + 1.42
B	Mo	-0.503	Y = -0.224X + 3.34
Mo	Al	0.766	Y = 16.9X - 7.46
Mo	Sr	0.569	Y = 4.10X - 0.322
Al	Sr	0.599	Y = 0.196X + 2.84
Sr	Ba	0.409	Y = 1.19X + 10.5
pH	Mn	-0.685	Y = -62.8X + 468

[1] Significant r at the 1% level = 0.456
Significant r at the 5% level = 0.355

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ESTIMATION OF CROP CONDITIONS AND SUGARCANE YIELDS USING AERIAL PHOTOGRAPHY

J. R. Thomas and G. F. Oerther, Jr.
Soil and Water Conservation Research
USDA, ARS, Southern Region
Weslaco, Texas

ABSTRACT

Aerial photography has been used to detect areas of low plant vigor. The objectives of this study were to (1) evaluate N stress effects on canopy reflectance of a sugarcane crop and (2) investigate the relations among selected crop characteristics, canopy reflectance, and yield. Different degrees of N stress were simulated by growing sugarcane variety NCo 310 at five N levels ranging from 0 to 200 lb/ac. Canopy reflectance was recorded photographically from an altitude of 1000 ft, using Kodak Aerochrome Infrared (CIR) film 2443 and Kodak Ektachrome MS Aerographic film 2448. Film-density readings were made with a microdensitometer. Near-infrared, red, and green canopy reflectance was measured approximately by using red, blue, and green bandpass filters. Sugarcane canopy reflectance was significantly affected by N fertilization, due mainly to the amount of vegetation. Plant density was significantly correlated ($r = 0.92^{**}$) with the optical density of CIR film. Near-infrared ($r_R = 0.91^{**}$), red ($r_G = 0.59^{**}$) and green ($r_B = 0.60^{**}$) canopy reflectance was significantly correlated with percent vegetative cover. However, the slopes of the regression lines, $b_R = 0.606$ (IR reflectance), $b_G = 0.093$ (red reflectance), and $b_B = 0.109$ (green reflectance) suggest that near-infrared canopy reflectance was more sensitive to changes in percent vegetative cover than were red or green canopy reflectance. The relation between sugarcane yields and near-infrared reflectance ($r = 0.87^{**}$) and the difference near-infrared minus red reflectance ($r = 0.90^{**}$) were highly significant. The degree of yield reduction caused by N stress was quantified by ratioing canopy reflectance in stressed vs nonstressed areas. Estimated yields were calculated as the product of the maximum or potential yield and the ratio. This prediction model overestimated field yield (mean of 20 plots) by 1.1%.

INTRODUCTION

Machinery and manpower allocation at harvest requires accurate information on sugarcane yield in each field. Using ground surveys to obtain this information is time-consuming and costly; also, in large fields, yield variations within the field are hard to detect and evaluate. Plant stress, induced by diseases, insects, nutrient deficiencies or toxicities, and drought, causes detectable changes in foliage reflectance and in plant density and cane height, characteristics that indicate crop vigor.

Aerial photography has been useful for detecting areas of low vigor caused by plant diseases (2), nutrient toxicities (3), and insects (4). Johnson (5) found with aerial photography that low vigor areas in sugarcane were easily located, but that the causative agents were difficult to identify. Thomas et al. (8, 9) and Stanhill et al. (6) found that photographically-measured reflectances from cotton and wheat fields, respectively, were strongly affected by the amount of vegetation and the percentage of ground covered be vegetation. Thomas and Gerbermann (7) reported that the amount of yield reduction in cabbage caused by N and water stress was related to the ratio of crop canopy reflectance in stressed vs nonstressed areas.

We conducted this study to: (1) measure the effect of N stress on sugarcane canopy reflectance; and (2) relate film optical densities to sugarcane yields.

MATERIALS AND METHODS

This investigation was conducted on sugarcane plots used for an N fertilization study--a full description of the experiment has been published (9). A third ratoon sugarcane (variety NCo 310) crop was treated with five levels of N (0, 50, 100, 150 and 200 lb/ac) applied as NH_4NO_3, with each treatment replicated four times. Each plot of the randomized complete block design consisted of 6 25-ft long rows of cane spaced 6 ft apart. Cane was hand harvested in January 1975 from 20 ft of the two center rows, and the number of millable stalks and total cane yields were determined.

Just before the cane lodged in August 1974, canopy reflectance was measured from aircraft, using photographs taken of the plots at 1000 ft altitude with Kodak Aerochrome Infrared (CIR) film 2443 and Kodak Ektachrome MS Aerographic (conventional color) film 2448. The films were exposed simultaneously in three 70-mm Hasselblad cameras with 80-mm focal-length lenses mounted to view the same area. A Hasselblad orange filter (4 X 0 - 2)[1] alone and with a Wratten CC20 blue filter was used with the CIR film. A haze filter (1 X HZ - 0) was used with the conventional color film. The 4 X 0 - 2 filter excludes wavelengths shorter than 520 nm. Use of the blue filter allowed the magenta tonal image to predominate which increases the contrast between plants and the soil background.

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[1] The numbers and letter indicate the filter factor, color, and exposure value reduction, respectively.

Optical density of each plot was obtained with a Joyce Loebl scanning microdensitometer. Optical counts (OC) of positive transparencies were measured with neutral, blue (410 to 495 nm), green (510 to 585 nm), and red (615 to 700 nm) bandpass filters in a tungsten light beam. Optical count readings were made by scanning across the sugarcane rows at three locations within each plot. The OC were converted to optical densities (OD) by the relation OD = (OC - base reading) (wedge factor) + step wedge density. The optical density values were changed to percentage transmission values (Log % T = 2 - OD) and combined algebraically to obtain values for the red minus blue and red minus green filter combinations.

Plant height was measured on five primary stalks in each plot at about 2-wk intervals. Ground level was marked with a stake, and the top visible dewlap was the uppermost reference point. Leaves numbered 3, 4, 5 and 6, counting from the top down, were collected from five stalks in each plot on the photographic date. After cleaning the leaves with a mild detergent, their midribs were removed and the remaining leaf tissue dried, ground, and total N determined by the Kjeldahl N method.

Analyses of variance and regression were used to evaluate the N stress effects on photographic data.

RESULTS AND DISCUSSION

Table 1 shows the effects of N fertilization on sugarcane yields, number of millable stalks at harvest, leaf N concentration, stalk height, and percentage of ground covered by vegetation on August 13, 1974. Nonfertilized sugarcane foliage was light greenish-yellow on the photographic date. The decrease in chlorophyll concentration induced by the N stress would decrease radiation absorption and increase reflectance (Thomas and Oerther, 1972); also, the significant change in foliage density and plant height would affect reflectance from the crop canopy.

Table 1. Effect of N fertilization on vegetative cover, plant height, millable stalks, leaf N content, and cane yields of NCo 310 on August 13, 1974.

N applied (lb/ac)	Vegetative cover (%)	Height (in.)	Millable stalks (no./ac)	Leaf N (%)	Yield (tons/ac)
0	82.0 a	54.6 a	32852 a	1.35 a	23.7 a
50	91.5 b	78.0 b	41065 b	1.47 b	44.7 b
100	93.3 b	78.2 b	45874 bc	1.51 b	48.8 b
150	97.5 b	83.6 b	48869 c	1.57 b	51.4 b
200	97.8 b	84.6 b	56628 d	1.62 b	50.1 b

Column means followed by a common letter are not significantly different at the 5% probability level, according to Duncan's multiple range test.

Variance analysis indicated that N fertilization significantly affected the optical densities of the images on the CIR films, but not those on the conventional color film (Table 2). The blue filter with the CIR film enhanced the red color of the foliage and increased the contrast between soil background and canopy reflectance. Foliage color and plant density differences among plots were readily apparent on a positive print of the conventional color film. Failure of the microdensitometer readings to show significant differences in OD on the conventional color film suggests that visible reflectance was less sensitive to changes in percent vegetation cover than was near-infrared reflectance. Infinite reflectance, defined as the maximum reflectance from leaves stacked sufficiently deep, simulates canopy reflectance and is reached in the visible spectral region (400 to 750 nm) with 2-leaf layers; whereas, in the near-infrared spectral region (750 to 1350 nm) 8-leaf layers are needed (1). Conventional color film is sensitive to visible light in the 360- to 680-nm spectralregion, while color infrared film (CIR) is sensitive to visible and near-infrared wavelengths of radiation (520 to 900 nm).

Table 2. Optical densities of film-filter combinations as affected by N fertilization of sugarcane.

N applied (lb/ac)	Film types and filters		
	2443[1]		2448[2]
	4 X 0 - 2	4 X 0 - 2 + CC20 B	1 X HZ - 0
0	1.195 a[3]	1.459 a	0.926 a
50	1.103 b	1.326 b	0.886 a
100	1.073 b	1.288 b	0.938 a
150	1.015 b	1.270 b	0.850 a
200	1.104 b	1.301 b	0.886 a

[1] Kodak Aerchrome Infrared film (CIR).

[2] Kodak Ektachrome MS Aerographic film (conventional).

[3] Column means followed by a common letter not significantly different at 5% probability level, according to Duncan's multiple range test.

The amounts of green, red and near-infrared light reflected from the sugarcane canopy were measured approximately on the CIR film by using blue, green, and red filters, respectively, in the microdensitometer. Data in Table 3 show that canopy reflectance was greater in the near-infrared spectral region and that reflectance in the green, red, and near-infrared regions increased with the rate of N fertilization. Optical densities of positive transparencies were inversely related to the amount of light reflected from the canopy. Discrimination among treatment effects was improved by using the bandpass filters.

Table 3. Optical densities of CIR transparency (2443) of sugarcane with white, red, blue and green-filtered light as affected by N fertilization.

N applied (lb/ac)	Bandpass filter[1]			
	Neutral	Red	Blue	Green
0	1.195 a[2]	.724 a	1.251 a	1.138 a
50	1.103 b	.613 b	1.156 ab	1.085 ab
100	1.073 b	.553 bc	1.142 b	1.040 b
150	1.015 b	.511 c	1.086 b	1.015 b
200	1.104 b	.533 bc	1.179 ab	1.086 ab

[1] Bandpass filters in light path of microdensitometer.

[2] Column means followed by a common letter not significantly different at 5% probability level according to Duncan's multiple range test.

Preharvest yield indicators generally used to estimate yields are plant density, expressed as the number of millable stalks per acre, and mean stalk weight. When these two parameters were determined at harvest, they accounted for 98% of the variation in sugarcane yields. We would not expect the relationship among yield, plant density, and mean stalk weight to be as strong if we had measured the yield indicators earlier in the season. However, the relative importance of the two yield factors should not change. Standard partial regression coefficients (b'y 1.2 = 0.6333 and b'y 2.1 = 0.0186) suggest that plant density had 34 times more effect than mean stalk weights in determining yields. The relation between yield and plant density is shown in Fig. 1. Yields are expressed as a percent of the maximum yield in each year. Maximum plot yields in 1973 and 1974 were 60.5 and 56.4 tons/ac, respectively. Plant density in 1974 was significantly correlated with optical density of the CIR films as measured with a red bandpass filter (Table 4).

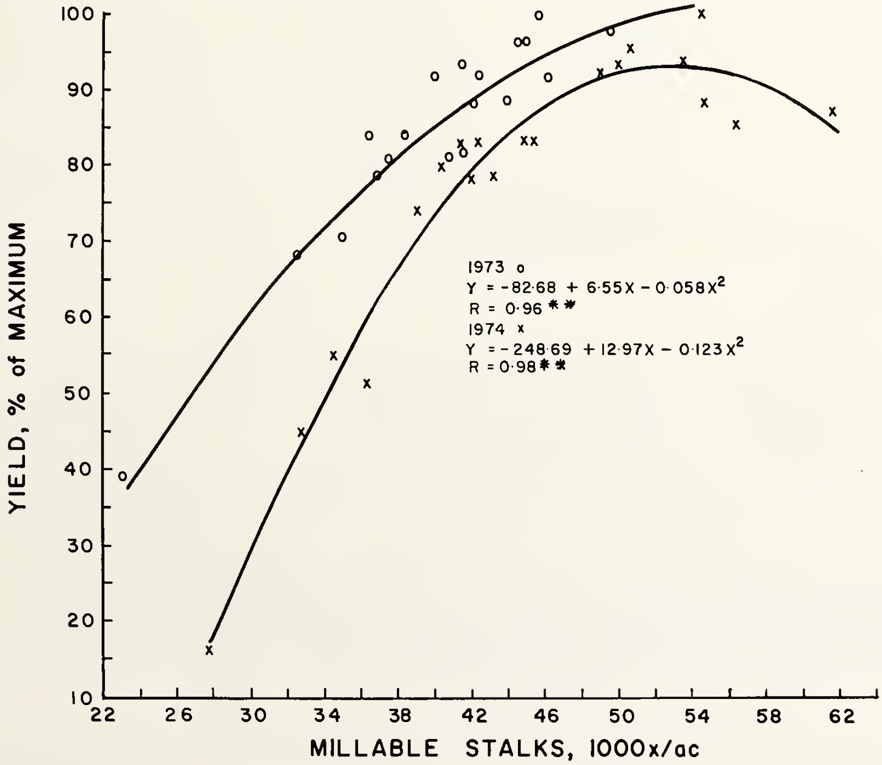

Figure 1. Relation of relative sugarcane yields to the number of millable stalks in 1973 and 1974.

Table 4. Regression equations expressing CIR film optical density (Y)[1/] as a function of plant density (X)[2/].

Filters	Regression model $Y = a + bx + cx^{2/}$	Correlation coefficient
4 X 0 - 2	$Y = 1.765 - 0.0469X + 0.0004X^{2/}$	0.895**
4 X 0 - 2 + CC20 B	$Y = 2.990 - 0.1029X + 0.0010X^{2/}$	0.917**

[1/] Red bandpass filter.
[2/] Millable stalks (number/ac ÷ 1000).

Canopy reflectance correlated significantly with percent vegetation cover. Fig. 2 shows that near-infrared canopy reflectance (red filter) was more sensitive to changes in percent vegetation cover than was red canopy reflectance (green filter). The sensitivity of near-infrared reflectance to increasing cover is due to the multiple scattering of light by the leaf layers (1). Correlation coefficients, $r_G = 0.59^{**}$ and $r_B = 0.60^{**}$, indicated a highly significant linear relation between percent vegetation cover and red and green canopy reflectance, respectively. However, the slope of the regression lines, $b_G = 0.093$ (red reflectance), and $b_B = 0.109$ (green reflectance), suggest that reflectance of red and green light was nearly insensitive to changes in vegetation cover. As green reflectance data overlaps the red reflectance data, it is not presented.

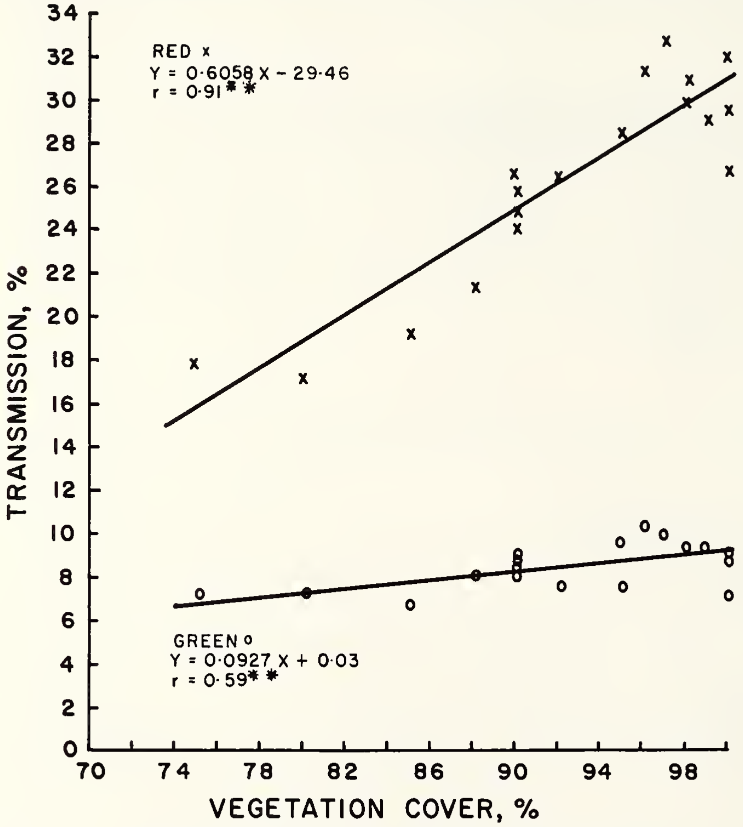

Figure 2. Percent transmission of CIR film measured with a red and green filter in the microdensitometer in relation to the percent vegetation cover.

Sugarcane yields were significantly correlated with percent vegetation cover (r = 0.94**) and with percent transmission of light (Table 5). The linear correlations were high (significant at the 1% level) when near-infrared reflectance (red filter) was used to discriminate among the treatments. The differences between near-infrared and red reflectance (R-G filter combination) and between near-infrared and green reflectance (R-B filter combination) seem to be the best indicators for predicting yields. Quadratic regression equations did not improve the correlations.

Table 5. Regression equations expressing sugarcane yields (Y, ton/ac) as a function of percent transmission of light (X) through different bandpass filters.

Bandpass filters[1]	Regression model $\hat{Y} = a + bx$	Standard errors of s_b	Standard errors of $s_{\bar{y}.x}$	Correlation coefficients
Neutral	$\hat{Y} = -10.89 + 6.65X$	±1.47	±8.23	0.740**
Red	$\hat{Y} = -15.73 + 2.24X$	±0.30	±5.97	0.873**
Green	$\hat{Y} = -6.69 + 5.89X$	±2.22	±6.62	0.581*
Blue	$\hat{Y} = 7.47 + 5.18X$	±2.02	±10.39	0.528*
Red-green	$\hat{Y} = -6.59 + 2.79X$	±0.32	±5.28	0.902**
Red-blue	$\hat{Y} = -9.78 + 2.74X$	±0.34	±5.71	0.885**

[1] CIR film with 4 X 0 - 2 filter.

The strong linear relationships among near-infrared canopy reflectance, plant density, percent vegetation cover, and sugarcane yields suggest that yields should decrease as does the ratio of reflectance in low vs high yield areas. Furthermore, the degree of yield decrease caused by N stress might be quantified by using this ratio. Reflectance was expressed as percent transmission of light through the film. Table 6 shows the yields at different N fertilizer levels as measured and estimated from percent transmission values using neutral, red, green, and blue filters in the microdensitometer. The estimated yields were calculated as the product of the maximum yield (Ym = 51.4 ton/ac) and the ratio of transmission in low vs high yield areas. Yield in the nonfertilized treatment was overestimated with all filters. These overestimations were partly caused by reflectance from vegetation other than sugarcane. In areas with 91.5 to 97.8% vegetation cover, yields were underestimated 5% with the red filter; whereas, with 82% vegetation cover yield was overestimated 33%.

Table 6. Sugarcane yields estimated from percent transmission of Kodak Aerochrome Infrared film (2443) with different filters.

Bandpass	N applied (lb/ac)				
filters	0	50	100	150	200
	- - - - - - - -	- - - - - - - -	Yield (tons/ac)	- - - - - - - -	- - - - - - - -
CIR film					
Neutral	33.9	42.0	45.0	51.4	41.9
Red	31.5	40.7	46.7	51.4	46.7
Green	38.8	43.7	48.5	51.4	43.6
Blue	35.2	43.7	45.2	51.4	41.5
CIR film and CC20 B filter					
Neutral	35.7	48.4	52.8	51.4	51.3
Red	25.8	38.7	50.0	51.4	47.9
Green	40.8	47.3	49.5	51.4	49.2
Blue	42.7	48.1	49.5	51.4	48.7
Measured yields	23.7	44.7	48.8	51.4	50.1

Reflectance from the soil background also contributed to the total reflectance. Since soils reflect mainly in the green and red wavelengths, the effects of soil background were minimized by substracting the percent transmission values of the photographs with neutral, blue, and green filtered light from that of the red filtered light. Yield estimates for nonfertilized sugarcane were improved by use of this normalization procedure (Table 7). The value of using a blue filter with CIR film to increase the contrast between the plants and soil background is also apparent.

Table 7. Sugarcane yields estimated from the difference in percent transmission between various bandpass filter combinations.

Bandpass filters	N applied (lb/ac) 0	50	100	150	200
	Yield (tons/ac)				
CIR film with 4 X 0 - 2 filter					
Red-blue	30.1	39.5	47.2	51.4	48.5
Red-green	28.2	39.2	45.8	51.4	48.1
Red-neutral	30.3	40.0	47.4	51.4	48.8
CIR film with 4 X 0 - 2 and CC20 B filters					
Red-blue	23.1	37.2	50.1	51.4	47.8
Red-green	19.2	35.0	50.2	51.4	47.3
Red-neutral	24.7	37.7	50.1	51.4	47.9
Measured yields	23.7	44.7	48.8	51.4	50.1

The computation of field yields is illustrated in Fig. 3. Sugarcane is red in the photograph and soils are dark. The sugarcane field is divided into 42 subunits which differ in percent vegetation cover. The potential yield of the highest yielding subunit (T_1a_1) is calculated from measurements of the number of millable stalks and mean stalk weight. The reduction in yield associated with stressed conditions in each subunit is assumed to be related to the ratio of light transmission in the low vs high yield area. Estimated field yield is the sum of the yield estimations in each delineated area as expressed by equation 1.

$$Y_E = \frac{Y_P}{T_1 A} \left[a_1 T_1 + a_2 T_2 + \ldots a_n T_n \right] \qquad 1$$

$$\Sigma a_n = A_{Total} \qquad 2$$

Where Y_E and Y_P are the estimated and potential field yield (tons/ac), T the mean percent transmission of the film for each subunit of area a. The total field area is expressed by equation 2. In this study, measured and estimated field yields were 43.7 and 44.3 tons/ac, respectively.

CONCLUSION

Results from this study agreed with results previously obtained with cabbage (7). Field areas where sugarcane growth was limited by low available N were detectable on aerial photographs. The decrease in yield associated with N stress caused a change in canopy reflectance. The amount of yield decrease was directly related to the ratio of crop canopy reflectance from stressed vs nonstressed areas.

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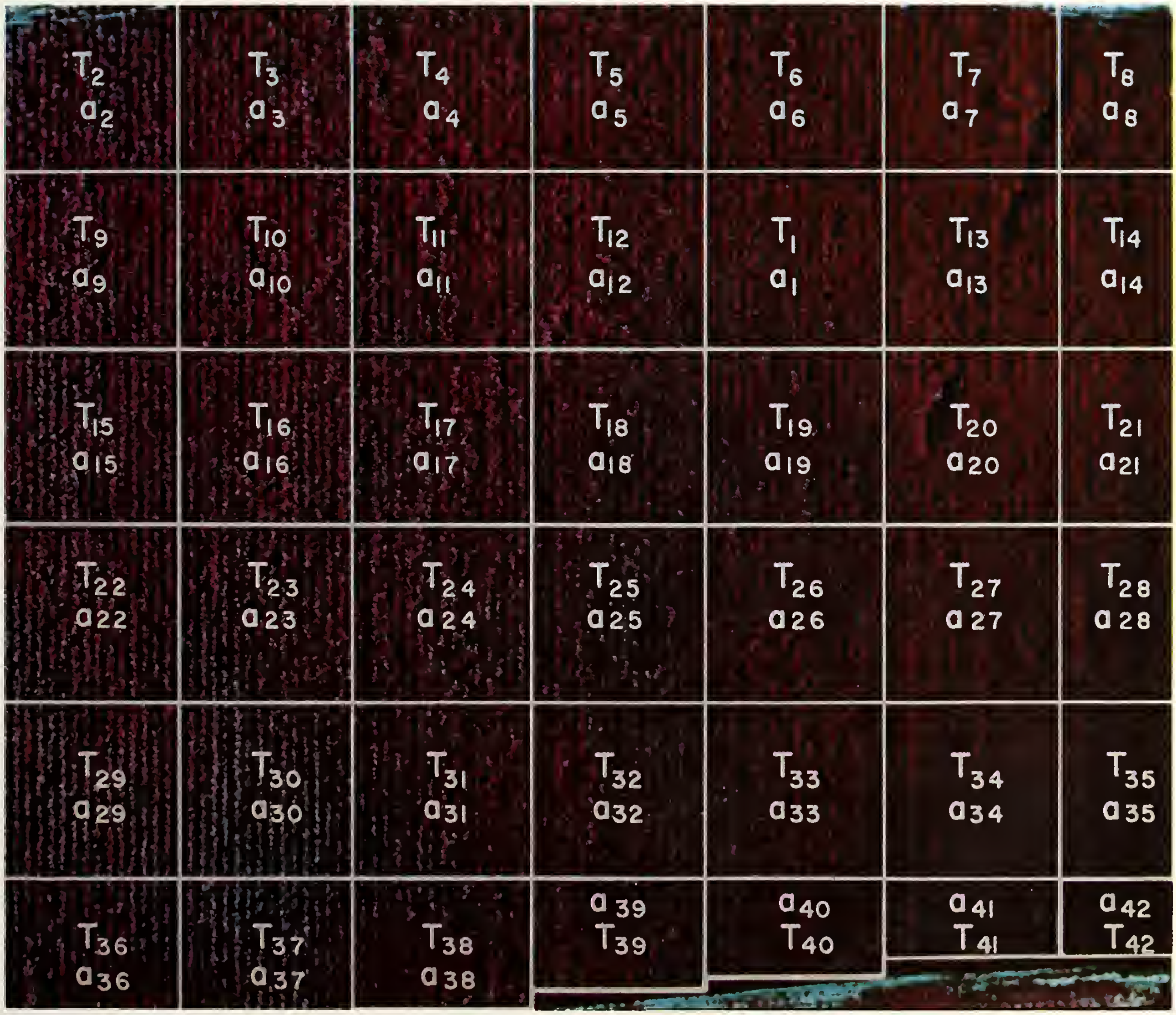

Figure 3. Near-infrared aerial photograph of a sugarcane field which has been subdivided in areas differing in percent vegetation cover.

ARTIFICIAL INOCULATION OF SUGARCANE SEEDLING PROGENIES TO INCREASE FREQUENCY OF MOSAIC RESISTANT CLONES

R. D. Breaux
U. S. Sugarcane Field Station
Houma, Louisiana

ABSTRACT

Seedlings of four sugarcane crosses were screened for mosaic resistance after being inoculated with sugarcane mosaic virus strain H in the greenhouse. Infection occurred in 80% of the seedlings and these were discarded. From the remaining healthy 20% of each of the four crosses, 50 seedlings were selected, field planted with 50 uninoculated-unscreened seedlings and grown to maturity. Ten plants of each clone, both inoculated and check, were grown from single-bud seed pieces, and the plants were again inoculated with mosaic. As controls, 60 plants of each of three varieties with known mosaic resistance were included. The percentage infection by mosaic was recorded for each clone. The control varieties responded to artificial inoculation as they did to natural field infection. Variety L 65-69, the most resistant control variety, had less than 10% mosaic-infected plants; CP 52-68, the least-resistant control variety, exceeded 90% infection. The screened progenies gave 2.4 times more resistant clones (10% or less infection) than did the unscreened progenies of the same crosses. The frequency of resistance was significantly higher after screening in three of four crosses, with the highest increase in frequency in the most susceptible progenies. Large field tests of natural infection under high disease incidence are under way.

RELATIONSHIP BETWEEN NUMBERS OF DIAGNOSTIC BACTERIA AND INJURY BY RATOON STUNTING DISEASE IN SUGARCANE

A. G. Gillaspie and G. Flax
USDA, ARS
Beltsville, Maryland
and
H. Koike
USDA, ARS
Houma, Louisiana

ABSTRACT

The number of diagnostic bacteria present in crude juice of various ratoon stunting disease (RSD)-infected sugarcane clones was determined by phase contrast microscopy. Sugarcane clones (CP 29-116, CP 52-68 and L 60-25) resistant to RSD injury, and clones (CP 36-105, CP 53-1, L 62-96 and L 65-69) susceptible to RSD injury, were grown from RSD-infected cuttings in the field at Houma, Louisiana. Three stalks of each clone were harvested in June, September, October and November, 1975. The stalks were milled separately, and various dilutions of the crude juice were assayed for infectivity on sugarcane clone CP 44-101. Diagnostic bacteria were counted in 10 microscope fields for each of two drops from every undiluted juice sample. Generally, the bacterial counts and the dilution end points of infectivity were directly related. Juice from clones resistant to RSD injury contained fewer diagnostic bacteria than did juice from susceptible clones. Thus, phase contrast microscopy may have potential as an improved method for screening sugarcane for resistance to RSD injury. The method is rapid and yields bacterial counts which correlate with clones resistant or susceptible to RSD injury.

ROGUING SUGARCANE MOSAIC USING GLYPHOSATE (ROUNDUP)

Hugh P. Fanguy and Donnie D. Garrison
U.S. Sugarcane Field Laboratory
Houma, Louisiana

ABSTRACT

Most of the Louisiana sugarcane crop is infected with the sugarcane mosaic virus. Growers are able to dig out mosaic-infected plants from seed plots where low levels of infection exist. It is very important that the most effective and economical method of roguing is available to growers who wish to continue this practice. Glyphosate was tested for chemical roguing of mosaic-infested plants in a field of CP 65-357 with 7.9% mosaic. Roundup (containing 41% glyphosate) was used at two rates, i.e., 3.3 and 6.7 cc per liter of water using a backpack sprayer on June 23, 1975. Both rates effectively stopped growth and killed all but a few terminal and lateral buds. The mosaic-infected plants were either dead or badly stunted when observed on September 9, 1975. The drift of glyphosate applied by the backpack sprayer killed neighboring healthy plants. Alternative methods of applying glyphosate to reduce drift will be discussed.

AERATED STEAM--ANOTHER METHOD OF CONTROLLING RATOON STUNTING DISEASE OF SUGARCANE

R. J. Steib, O. M. Cifuentes, B. J. Cochran, and M. M. Mayeux
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

Aerated steam (AS), a mixture of air and steam, showed promise in 1974 as a new method of controlling the ratoon stunting disease (RSD). Further studies indicated the hot-air (HA) oven now used in Louisiana could be converted to AS. Good germination and RSD control seemed possible from 1974 studies. The aims of the studies being reported were to find the best AS temperature-time combination for best germination and RSD control (cane treated with adhering trash), as well as variety tolerance and effects of pre-treatment storage on germination. In 1974, AS at 49 C-four hours, gave limited RSD control and 50 C-four hours was found to be much more effective, with excellent germination. From greenhouse studies in 1975, using cane with trash for treatment with AS, 50 C-four hours gave 97.0% control of RSD, an average for six varieties. Juvenile and mature node symptoms were used to identify RSD in four-month-old plants grown in the greenhouse. Cane with trash was also treated with AS at 51 C-four hours in an oven one-third larger than the commercial HA oven. In one large greenhouse test, germination and RSD control in CP 44-101, L 62-96 and CP 65-357 were both excellent. Thermocouple checks at 14 points in the large oven reached equilibrium in one hour. The same larger commercial oven was used for six weeks in the process of treating four varieties at 51 C-four hours (cane with trash) in the fall of 1975. Fall and spring germination was excellent. Preliminary tests over two years showed it may be possible to use a higher temperature with a reduced treatment period. A delay period before treating with AS after cutting was found less injurious than HA. Results of experimental and commercial-scale tests over two years indicate AS may be used to control RSD. Due to the many advantages of AS over HA, it is being made available to the Louisiana industry in 1976 as an additional method of RSD control besides the HA and hot-water treatments now being used.

A COMPARISON OF THE SEXUAL ATTRACTIVENESS, FERTILITY, AND FECUNDITY OF LABORATORY-REARED AND WILD ADULT SUGARCANE BORERS[1]

James W. Sanford
U.S. Sugarcane Field Laboratory
Southern Region, ARS, USDA
Houma, Louisiana 70361

ABSTRACT

Traps baited with laboratory-reared female sugarcane borer moths, Diatraea saccharalis (F.), captured slightly more wild males than traps baited with wild females. The fertility and fecundity of laboratory-reared and wild females did not differ, but wild males were more fertile than laboratory-reared males.

INTRODUCTION

Mass-reared sterile insects are presently being released to control the screwworm, Cochliomyia hominivorax (Coquerel), in the southwestern U.S., to prevent the Mexican fruit fly, Anastrepha ludens (Lowe), from entering California from Mexico, and to prevent the spread of the pink bollworm, Pectinophora gossypiella (Saunders), to uninfested cotton-producing areas in the United States. Mass-reared insects are also used to artificially infest plants in host plant resistance studies and in a number of pilot tests of genetic and biological control (3). In some of these programs, the behavior of the mass-reared insects has become unsatisfactory, a development usually attributed largely to adaptive hereditary changes during many generations of laboratory colonization. However, the success of pest management programs often depends on the adequate field performance of mass-reared released insects. It is therefore important to identify and correct any deficiencies present in the laboratory colonies.

At the Sugarcane Field Laboratory, the sugarcane borer, Diatraea saccharalis (F.), is reared for use in tests of inherited sterility, biological control, and host plant resistance. In view of the importance of these laboratory-reared insects to the research effort, I recently began a program to measure and evaluate the performance of laboratory-reared sugarcane borers by comparing them with non-laboratory reared (hereafter referred to as wild) sugarcane borers. The work reported here was undertaken in an effort to compare the attractiveness, fertility, and fecundity of laboratory-reared and wild sugarcane borer females.

MATERIALS AND METHODS

The laboratory insects used in the test were taken from a colony maintained in the laboratory for 7 generations, ca. 8 months. This colony was started from larvae collected in the field in the Terrebonne Parish area of Louisiana. The test larvae were reared in individual 1-oz plastic jelly cups on the diet of Burton (1), which had been modified by substituting dried ground-up sugarcane leaves for one-half the pinto beans in the diet, and were held at 27 ± 2 C and about 80% RH, in continuous light. Pupae were sexed and held at 26 C in a 14-h light:10-h dark photoperiod. Males and females were held in separate cages at the same photoperiod to insure that only virgin females and unmated males were used in the tests.

The wild insects used in the test were collected as pupae or late-instar larvae from 4 locations in Terrebonne Parish. Each larva was placed in a 1-oz jelly cup of artificial diet and allowed to complete development. The pupae were sexed, placed in separate cages, and were held at conditions similar to those provided for the laboratory-reared larvae and pupae as were the emerging adults.

The first test was made in a field of CP 65-357 first-stubble sugarcane at the Houma station to compare the attraction of females from the 2 sources. Twelve sex attractant traps (3.8-liter paper cartons with both ends removed and the interior coated with Stikem Special) were hung from sugarcane plants with a piece of string. Five were baited with laboratory-reared females, 5 were baited with wild females, and 2 were unbaited. The bait was a single virgin female less than 24 h old placed in a 8 x 4-cm wire cage; 1 such cage was suspended from a wire hook in the top of each trap. The first part of the study was conducted June 5-Aug. 15 and the second part Aug. 16-Sept. 24. In the first trial, the traps were placed in the field in a completely randomized block design with 15 m between traps; then the traps were re-randomized every other day. In the second trial, the traps were arranged in pairs, one of which contained a laboratory-reared female and the other a wild female; one trap of a pair was placed on a sugarcane plant in one row, and the other was placed directly across from it, about 1 m away, on a plant in the adjacent row. The traps were arranged in a straight line down the 2 rows with 15 m between each pair. The position of the 2 traps in each pair was alternated daily.

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[1] Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

In both trials, the traps were checked daily, and the catch of males from the previous night was removed. Females were replaced every other day unless one died sooner, which seldom occurred; at the same time as needed, traps were replaced or recoated with Stikem Special. The data from the 2 trials were analyzed separately by a combined analysis of variance.

The second test was made in the laboratory to determine the fertility and fecundity of laboratory reared (L) and wild (W) sugarcane borers. Four series of crosses were arranged: L♂ x L♀, W♂ x L♀, L♂ x W♀, and W♂ x W♀. One unmated male less than 24 h old was placed with a virgin female of like age in a 1-pt cardboard carton with a compression seal plastic lid. A piece of moist cotton placed in each carton maintained high humidity and provided water for the moths. The cartons were held in a 14-h light: 10-h dark photoperiod at 27 ± 2 C. Eggs were deposited on the inner surface of the carton and lid. When the eggs in the carton began to hatch, any moths that were still alive were removed and placed in separate cartons to complete oviposition. At death all female moths were dissected, and the bursa copulatrix was examined to determine the number of spermatophores present. Fecundity was determined from the eggs laid by each female and fertility from the percentage of eggs that hatched.

RESULTS

Female attractiveness. In the first trial of female attractiveness, the traps baited with laboratory-reared females caught 416 males, while the traps baited with wild females caught 371 males. In the second trial, the traps baited with laboratory females caught 282 males while the traps baited with wild females caught 252 males. The analysis showed no significant difference between the number of males attracted by laboratory-reared and wild females in either trial.

Fertility and fecundity. Data from the test of fertility and fecundity are shown in Table 1. Wild males effected a significantly higher percentage egg hatch than laboratory males, that is, the W♂ x L♀ and W♂ x W♀ crosses both had higher average percentage egg hatch than did the L♂ x L♀ and L♂ x W♀ crosses. There was no significant difference in fecundity among the females in any of the 4 pairings, and there was no significant difference in the number of spermatophores per female.

Table 1. Fertility and fecundity of laboratory-reared (L) and wild (W) sugarcane borer moths.

Cross	No. pairs	Average % egg hatch[a/]	Average no. eggs/♀
L♂ x W♀	55	74.0 a	575 a
L♂ x L♀	59	76.2 a	597 a
W♂ x L♀	58	85.5 b	613 a
W♂ x W♀	59	85.9 b	599 a

[a/] Analysis conducted on arcsin transformation of percentage egg hatch; retransformed figures given. Means followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

DISCUSSION

Perez and Long (4) were the first to demonstrate the presence of a chemical sex attractant in the female sugarcane borer (4): they found that the moths were most attractive during the first 3 days of life. Sower et al. (6), working with the almond moth, Cadra cautella (Walker), found no significant differences between the output of pheromone by W and L females or between the responsiveness of wild or laboratory-reared males to W and L females. Richerson and Cameron (5) reported that wild female gypsy moths, Lymantria (=Porthetria) dispar (L.), were more attractive to wild males than laboratory-reared females and concluded that rearing the gypsy moth on artificial diet and/or the rearing conditions may have caused the reduced output of pheromone by laboratory-reared females. Flint et al. (2) found no difference between the attractiveness of mass-reared and field-collected female pink bollworms, Pectinophora gossypiella (Saunders). My results also indicate that there is no difference between the attractiveness of wild and laboratory-reared sugarcane borer females.

The cause of the reduced fertility of our laboratory-reared males is unknown. It may result from a dietary deficiency or from less than optimum rearing conditions.

In sum, I found no difference among females in the sexual attractiveness or fecundity between laboratory-reared and wild populations, but laboratory-reared males were less fertile than wild males.

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PRE- AND POSTEMERGENCE HERBICIDES IN LOUISIANA SUGARCANE

Ernest R. Stamper
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

The weed and grass control recommendations of herbicides for 1976 include eight preemergence chemicals, three pre- and postemergence, and one postemergence for use in Louisiana sugarcane. Only four of the preemergence chemicals are generally used; the other four chemicals are used in specific areas in the sugarcane belt. The pre- and postemergence herbicides are generally used throughout the Louisiana sugarcane industry but have little or no use in other sugarcane growing areas of the world. Dalapon is the only postemergence herbicide mentioned in the 1976 general recommendations however, Asulox is suggested for use in a supplemental recommendation prepared after the general recommendations were written.

Louisiana sugarcane growers may select from eight preemergence chemicals for controlling weeds and grasses in their crop. These chemicals are, Karmex, Princep, Treflan, Cotoran, Fenac, Sinbar, AAtrex, and silvex; however, only four are generally used and some are used for specific weed or grass control.

Fenac, Sinbar, Treflan, and silvex are used more than the others mentioned. Treflan is used for the control of itchgrass and to some extent in the cotton growing areas on sugarcane. These preemergence chemicals are used mostly on plant sugarcane but may, under some conditions, be used on stubble sugarcane.

Karmex, Princep, AAtrex, and Cotoran are very weak in controlling johnsongrass seedlings and are not generally used where johnsongrass seedlings are known to exist.

Three new chemical herbicide candidates have been tested and evaluated in the past several years. These three candidates are, Chemagro's Sencor, Elanco's Spike, and Dupont's Velpar. All three of these chemicals are in the process of being registered and labeled for use in sugarcane.

The comparative effects of these materials on grass control and the yield of sugarcane are shown in Tables 1, 2, 3, 4. Tables 1 and 2 show the results when the chemicals were used on two varieties of plant sugarcane. Many combinations of chemicals and changing treatments in spring from the fall are shown in Tables 1 and 2. This shifting has been evaluated to attempt to have data in case some grass or broadleaf weed should become resistant or immune to the use of a single chemical.

Table 1. The comparative effect of several preemergence herbicides used at different rates and combinations on grass control and the yield of plant sugarcane 1974-75, variety CP 48-103 at Alma Plantation.

Treatment and rate/acre						
Fall 1974	Spring 1975	Tons cane/acre	% sucrose normal juice	Lb sugar/ton cane	Lb sugar/acre	% of control
Untreated check	Check	10.8	14.97	215.8	2331	-
Sencor 1 1/2 lb[1]	Fenac 2 qt & Sinbar 1/2 lb	36.0	15.30	221.3	7967	93.0
Fenac 4 qt & Silvex 1 lb	Repeat	33.3	14.82	214.1	7130	84.0
Sencor 1 1/2 lb	Sinbar 2/3	33.1	14.66	210.5	7117	87.0
Sinbar 2/3 lb	Fenac 4 qt & Silvex 1 lb	33.7	14.67	210.7	7100	95.0
Spike 3/4 lb	Sinbar 2/3 lb	31.3	15.16	219.0	6855	73.0
Velpar 1/4 lb	Repeat	32.5	14.48	207.5	6744	95.0
Sinbar 2/3 lb	Repeat	33.7	13.93	198.2	6679	95.0
Sinbar 2/3 lb	Sinbar 1/2 lb & Fenac 2 qt	31.4	14.70	211.2	6632	86.0
- -	Velpar 1 lb	31.5	14.34	205.2	6464	97.0
- -	Spike 3/4 lb	30.0	14.67	210.7	6321	97.0
Spike 3/4 lb	Repeat	32.2	13.74	194.9	6276	90.0
- -	Velpar 1/2 lb	27.9	14.79	212.7	5934	89.0

(Continued)

Table 1. Continued

Treatment and rate/acre						
Fall 1974	Spring 1975	Tons cane/acre	% sucrose normal juice	Lb sugar/ton cane	Lb sugar/acre	% of control
Fenac 4 qt & Silvex 1 lb	Sencor 1 1/2 lb	24.8	15.02	216.6	5372	90.0
Velpar 1/2 lb & Fenac 2 qt	Repeat	26.1	14.08	200.8	5241	96.0
Lexon 1 1/2 lb	Repeat	24.7	14.73	211.7	5229	94.0
Sencor 1 1/2 lb	Repeat	26.1	13.73	194.7	5082	93.0
Velpar 1/2 lb	Repeat	23.4	14.73	211.7	4954	89.0
Fenac 2 qt & Sinbar 1/2 lb	Repeat	23.0	12.94	180.9	4161	95.0
Sinbar 2/3 lb	Velpar 1/2 lb	19.0	13.62	192.8	3663	90.0
Velpar 1 lb	Repeat	15.4	12.31	169.8	2615	96.0

1/Sencor, Lexon, Velpar, Spike, and Sinbar all wettable or water soluble powders and were used as commercial formulations and not active ingredients.

Fall application - Sept. 23, 1974; Spring application - April 2-3, 1975; Band application on 30 inches or 5/12 broadcast rate.

Table 2. The effect of several preemergence herbicides used at different rates and combinations on grass control and the yield of plant sugarcane 1974-75, variety CP 65-357 at Alma Plantation.

Treatment and rate/acre						
Fall 1974	Spring 1975	Tons cane/acre	% sucrose normal juice	Lb sugar/ton cane	Lb sugar/acre	% of control
Untreated check	--	17.9	15.33	221.8	3970	--
Velpar 1/2 lb[1]	Repeat	33.0	15.42	233.2	7696	86.0
Spike 3/4 lb	Repeat	33.3	14.98	216.0	7193	97.0
Fenac 4 qt & Silvex 1 lb	Repeat	31.9	15.53	225.1	7181	95.0
Sencor 1 1/2 lb	Repeat	30.8	15.95	232.2	7152	93.0
Lexon 1 1/2 lb	Repeat	30.0	15.56	225.6	6768	94.0
Sinbar 2/3 lb	Repeat	31.0	14.99	216.1	6699	95.0
Velpar 1/2 lb & Fenac 2 qt	Repeat	25.4	15.22	219.9	5585	90.0
Velpar 1 lb	Repeat	22.4	13.85	196.8	4408	85.0

1/Velpar, Spike, Sinbar, Sencor, and Lexon are all wettable or water soluble materials and are used at the commercially formulated rate. Applied on a 30 inch band 5/12 total broadcast area.

Fall application - Sept. 23, 1974; Spring application - April 2-3, 1975.

The results in Tables 3 and 4 show data on the use of a single chemical in stubble cane to look for immune weeds and grasses. These two tables show the results of work done at St. Gabriel where a single chemical has been used in plant cane and first stubble. This work is being continued and a new planting is to be started in 1976 to repeat and continue the work. Two varieties are used in the St. Gabriel work. This allows new varieties of sugarcane to be under chemical treatment several years before they are evaluated in outfield tests.

After harvest in 1976 these two varieties will be plowed and the land will be fallow plowed in 1977 and replanted. The same chemical herbicide will be applied to the same area in future years to attempt to produce a weed population that is resistant or immune to a certain chemical herbicide.

Tables 5, 6, 7, 8, and 9 show the results and data from stubble sugarcane where Asulox and combinations of other chemicals were evaluated. These data include the percent grass control, the yield of sugarcane in tons per acre, and other yield information.

From these and other data accumulated over a period of several years, it appears that Asulox will become a very good tool for Louisiana sugarcane growers to use in the fight against johnsongrass and other grasses that grow with wide large leaves. Asulox is not effective against the small narrow leaf grasses, such as bermudagrass.

Table 3. The effect of repeated applications of herbicides on plant and first stubble sugarcane at St. Gabriel on weed control and yield of sugarcane - 1973-74-75, variety L 62-96.

Treatment and rate/acre							
Fall 1973	Spring 1974	Spring 1975	Tons cane/acre	% sucrose normal juice	Lb sugar/ton cane	Lb sugar/acre	% of control
Untreated check	-	-	10.3	15.59	226.1	2329	-
Sinbar 2/3 lb1/	2/3 lb	1 lb	19.1	15.70	228.0	4355	83.0
Sencor 1 1/2 lb	1 1/2 lb	2 lb	20.3	14.59	209.3	4249	80.0
Fenac 4 qt2/	Sinbar 2/3 lb	Velpar 1 lb	18.6	15.70	228.0	4241	85.0
Fenac 4 qt3/	4 qt	4 qt	17.1	16.00	233.0	3984	80.0
Spike 3/4 lb	3/4 lb	1 1/2 lb	18.0	15.14	218.6	3935	78.0
Sencor 1 1/2 lb	Sinbar 2/3 lb	Velpar 1/2 lb	16.0	15.39	222.8	3648	81.0
Sinbar 2/3 lb	Fenac 4 qt	Fenac 4 qt	13.8	15.38	222.7	3073	76.0
Sinbar 2/3 lb	Sencor 1 lb	Sencor 2 lb	14.7	15.30	221.3	2360	93.0
Spike 1/2 lb	1/2 lb	1/2 lb	11.4	13.91	197.9	2256	84.0

1/Sinbar, Sencor, Spike, and Velpar used as commercial products.
2/Fenac used with 1 lb Silvex per acre.
3/All applications made on a 30 inch band 5/12 total area.

Table 4. The effect of repeated applications of herbicides on plant and first stubble sugarcane at St. Gabriel on weed control and yield of sugarcane - 1973-74-75, variety CP 65-357.

Treatment and rate/acre							
Fall 1973	Spring 1974	Spring 1975	Tons cane/acre	% sucrose normal juice	Lb sugar/ton cane	Lb sugar/acre	% of control
Untreated check	-	-	18.1	14.11	201.0	3638	-
Sinbar 2/3 lb1/	Sencor 1 1/2 lb	Sencor 2 lb	30.6	13.28	186.9	5719	96.0
Fenac 4 qt2/	4 qt	4 qt	28.2	13.07	183.2	5166	93.0
Sencor 1 1/2 lb3/	Sinbar 2/3 lb	Velpar 1/2 lb	24.2	13.36	188.3	4557	93.0
Sinbar 2/3 lb	Fenac 4 qt	Fenac 4 qt	21.9	14.12	201.4	4411	94.0
Sencor 1 1/2 lb	1 1/2 lb	2 lb	21.9	13.95	198.6	4349	92.0
Spike 1 lb	1 lb	1 1/2 lb	22.7	13.47	190.2	4318	98.0
Fenac 4 qt	Sinbar 2/3 lb	Velpar 1 lb	21.6	14.00	199.4	4307	95.0
Sinbar 2/3 lb	2/3 lb	1 lb	20.9	12.82	178.8	3737	95.0
Spike 1/2 lb	1/2 lb	3/4 lb	18.6	12.77	178.0	3311	88.0

1/Sinbar, Sencor, Spike, and Velpar used as commercial products.
2/Fenac used with 1 lb Silvex per acre.
3/All applications made on a 30 inch band 5/12 total area.

Table 5. The effect of Asulox applied to second year stubble sugarcane for johnsongrass control. 1975, variety CP 61-37.

Treatment and rate/acre	Tons cane/acre	% normal juice sucrose	Lb sugar/ton cane	Lb sugar/acre	% grass control
Plantation practice1/	13.4	14.87	214.1	2869	65.0
3 qt Asulox + 1 1/2 lb dalapon2/	22.3	15.17	219.9	4886	75.0
4 qt Asulox	22.7	14.49	207.6	4713	81.0
2 qt Asulox + 1 1/2 lb dalapon	20.5	15.07	217.5	4459	70.0

1/Two applications of dalapon at 2 1/2-2 lb per acre plus 1 lb silvex--applied by airplane.
2/One lb of silvex per acre applied with all treatments. Ground application on 1/2 to 2/3 total area.

Table 6. The effect of Asulox and combinations of Asulox and dalapon on grass control and the yield of second year stubble sugarcane where 4 qt of Asulox were applied in the fall to cane cut for seed in 1973.

Treatment and rate/acre 1974-1975	Tons cane/acre	% normal juice sucrose	Lb sugar/ton cane	Lb sugar/acre	% grass control
Untreated check	3.2	14.15	202.0	646	--
Plantation practice[1]	12.2	13.49	190.5	2324	50.0
	Applied April 10, 1974				
4 qt Asulox[2]	23.3	14.57	209.0	4870	95.0
2 qt Asulox	23.6	14.28	204.2	4819	81.0
3 qt Asulox	22.3	13.68	192.9	4302	--
	Applied April 30, 1974				
Check	5.2	14.34	205.2	1067	--
4 qt Asulox	31.9	14.85	213.8	6820	96.0
3 qt Asulox	27.1	14.20	202.8	5496	87.0
3 qt Asulox + 1 1/2 lb dalapon	27.3	13.91	197.9	5403	91.0
2 qt Asulox	22.4	14.83	213.4	4708	83.0
2 qt Asulox + 1 1/2 lb dalapon	24.1	13.92	198.0	4771	86.0

[1] Plantation practice 2 1/2 lb dalapon + 2 lb dalapon + 1 lb silvex 21 days later--applied with an airplane.
[2] Asulox applied to 1/2 to 2/3 total area + 1 lb of silvex per acre.

Table 7. The effect of Asulox and combinations of Asulox and dalapon at different rates and dates of application on grass control and the yield of sugarcane in second stubble on Alma Plantation, variety CP 48-103--1975. Cane cut for seed and no Asulox applied in fall 1973.

Treatment and rate/acre applied 1974-1975[1]	Tons cane/acre	% normal juice sucrose	Lb sugar/ton cane	Lb sugar/acre	% grass control
Untreated check	6.3	14.14	201.7	1271	--
	Applied April 10, 1974				
2 qt Asulox + 1 1/2 lb dalapon[2]	23.2	14.31	204.7	4749	81.0
4 qt Asulox	21.2	14.03	199.9	4238	90.0
2 qt Asulox	20.6	14.09	200.9	4139	72.0
	Applied April 30, 1974				
4 qt Asulox	28.5	14.24	203.5	5800	95.0
3 qt Asulox + 1 1/2 lb dalapon	25.5	14.66	210.5	5368	86.0
3 qt Asulox	26.1	14.08	200.8	5241	83.0

[1] All applications made on April 23, 1975.
[2] All applications made with 1 lb of silvex per acre. Ground application on 1/2 to 2/3 total area.

Table 8. The effect of Asulox and combinations of Asulox and dalapon on grass control and sugarcane yields of second year stubble sugarcane where two qt of Asulox were applied on cane cut for seed in the fall of 1973, variety CP 48-103 on Alma Plantation.

Treatment and rate/acre 1974-1975	Tons cane/acre	% normal juice sucrose	Lb sugar/ton cane	Lb sugar/acre	% grass control
	Applied April 10, 1974				
Untreated check	6.1	14.71	211.4	1290	--
Plantation practice[1/]	11.6	14.00	199.4	2313	55.0
4 qt Asulox[2/]	25.3	13.33	187.7	4749	96.0
3 qt Asulox	18.6	14.93	215.1	4001	81.0
2 qt Asulox	15.6	12.90	180.2	2811	65.0
	Applied April 30, 1974				
Untreated check	6.3	14.72	211.5	1332	--
4 qt + 4 qt Asulox	34.3	14.33	205.0	7032	94.0
4 qt Asulox	28.0	15.19	219.4	6143	95.0
3 qt Asulox	24.7	14.98	216.0	5335	88.0
3 qt Asulox + 1 1/2 lb dalapon	23.6	14.66	210.5	4968	90.0
2 qt Asulox + 1 1/2 lb dalapon	22.6	15.17	219.7	4952	86.0
2 qt Asulox	15.0	15.38	222.6	3339	67.0

[1/] Plantation practice 2 1/2 lb dalapon + a second application of 2 lb dalapon 21 days later. Silvex at 1 lb per acre added.

[2/] All applications with 1 lb of silvex per acre added. Ground application on 1/2 to 2/3 total area.

Table 9. The effect of Asulox and combinations of Asulox and dalapon on johnsongrass control and the yield of first year stubble sugarcane at Alma Plantation--1974-1975, variety CP 61-37.

Treatment and rate/acre		Tons	% normal juice	Lb sugar/ton	Lb	% weed and grass
Fall 1974	Spring 1975	cane/acre	sucrose	cane	sugar/acre	control
Untreated check	Check	13.0	14.11	201.3	2617	--
Plantation practice[1/]	--	21.6	14.76	212.2	4584	78.0
3 qt Asulox[2/]	3 qt Asulox	36.2	14.00	199.4	7218	95.0
3 qt Asulox	3 qt Asulox	34.4	14.51	208.0	7155	94.0
3 qt Asulox	3 qt Asulox	34.5	14.32	204.8	7066	94.0
--	3 qt Asulox	33.7	14.23	203.3	6851	95.0
--	2 qt Asulox	32.6	14.43	206.7	6738	91.0
4 qt Asulox	4 qt Asulox	31.5	14.28	204.2	6432	96.0
--	2 qt Asulox	30.8	14.51	208.2	6406	94.0
4 qt Asulox	--	30.5	13.93	198.2	6045	95.0
2 qt Asulox	2 qt Asulox	29.7	14.00	199.4	5922	94.0
--	3 qt Asulox	27.9	14.27	204.0	5692	94.0
--	4 qt Asulox	27.1	14.17	202.3	5482	95.0
4 qt Asulox	4 qt Asulox + 1 1/2 lb dalapon	25.2	14.67	210.7	5309	90.0
2 qt Asulox	--	23.8	15.20	219.6	5226	86.0
3 qt Asulox	3 qt Asulox + 1 1/2 lb dalapon	25.5	14.24	203.5	5189	85.0
--	3 qt Asulox + 1 1/2 lb dalapon	24.4	14.47	207.3	5058	89.0
2 qt Asulox	2 qt Asulox + 1 1/2 lb dalapon	20.8	14.66	210.5	4378	76.0
3 qt Asulox	--	18.7	14.42	206.5	3862	95.0
--	2 qt Asulox + 1 1/2 lb dalapon	19.6	13.63	192.9	3781	89.0

[1/] Plantation practice--two applications of dalapon at 2 1/2 lb + 2 lb + 1 lb of silvex per acre applied by airplane at 21 day intervals.

[2/] Applied to 1/2 to 2/3 the area with 1 lb of silvex per acre. All Asulox applications or combinations of Asulox and dalapon.

The time of application is very important in using Asulox for its maximum effect. One application is not effective when used alone and it is not economically feasible to make two applications of Asulox, if it was labeled to make two applications.

From these data it may be seen that the low rates of Asulox are increased in effectiveness by the addition of dalapon but less response is shown with the higher rates of Asulox. This is especially true with the 2 and 3 quart per acre application.

Fall application followed by spring application does not give sufficient increase in yield of sugarcane to justify the fall application (Table 9). The spring application alone at the higher rates was as effective as the fall and spring application. Previous work showed that fall application was not effective in controlling johnsongrass.

CONTROLLING BROWNTOP PANICUM IN SUGARCANE[1]

R. W. Millhollon
Agricultural Research Service, USDA
Houma, Louisiana 70361

ABSTRACT

Browntop panicum (*Panicum fasiculatum* Swartz.) became a problem in Louisiana sugarcane for the first time about 1971 because it was not controlled by the widely used herbicide terbacil (3-*tert*-butyl-5-chloro-6-methyluracil). The control by several herbicides evaluated as preemergence treatments were: fenac [(2,3,6-trichlorophenyl)acetic acid] at 1, 2, and 4 lb/A - 74%, 99%, and 100%, respectively; soil-incorporated trifluralin (*a*,*a*,*a*-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine) at 2 lb/A - 74%; metribuzin [4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5(4*H*)-one] at 2 lb/A - 35%; tebuthiuron (*N*-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N*,*N'*-dimethylurea) at 2 lb/A - 49%; and terbacil at 1.6 and 3.2 lb/A - 9% and 29%, respectively. Fenac at 1.8 lb/A applied on a 30-in. band over sugarcane in spring and broadcast at lay-by, with routine cultivation, controlled browntop panicum almost perfectly for the entire growing season. Browntop panicum 10 to 12 in. tall was also effectively controlled by foliar applications of dalapon (2,2-dichloropriopionic acid) at 2.4 and 3.4 lb/A; MSMA (monosodium methanearsonate) at 2 lb/A; and ametryn [2-(ethylamino)-4-(isopropylamino)-6-(methylthio)-*s*-triazine] at 2.5 and 3.5 lb/A. Asulam (methyl sulfanilylcarbamate) at 3 and 4 lb/A stunted plants but did not kill them. Uncontrolled browntop panicum that developed only sparsely on the sugarcane drill in spring, but profusely after lay-by, reduced the yield of cane/A for CP 61-37 sugarcane only by about 6% as compared to a hand-weeded check.

INTRODUCTION

Heavy infestation of browntop panicum first appeared in Louisiana sugarcane about 1971. It had been part of the weed flora in sugarcane but previously had not been economically important. Investigation showed that heavily infested fields had been treated repeatedly over several years with terbacil, a herbicide widely used in Louisiana sugarcane. Terbacil controls johnsongrass [*Sorghum halepense* (L.) Pers.] from seed and almost all other annual grass and broadleaved weeds in sugarcane, but obviously was not controlling browntop panicum.

Browntop panicum is a tropical grass that occurs in moist open ground, often as a weed of fields, in the southernmost parts of the United States and at low elevations in tropical America (4). In Louisiana sugarcane, infestations occur in summer after planting, in spring, and in summer after lay-by. It reproduces only by seed, but many seed are produced in summer and autumn. It is easily identified when in flower by the large brown panicles (seed heads).

In irrigated cotton in Arizona, browntop panicum [var. *reticulatum* (Torr.) Beal] has been controlled with several soil-incorporated dinitroanaline herbicides including trifluralin. Control was also achieved with soil-incorporated bensulide [*O*,*O*-diisopropyl phosphorodithioate *S*-ester with *N*-(2-mercaptoethyl) benzenesulfonamide] (2,3).

In this study I evaluated several herbicides for preemergence and postemergence control of browntop panicum.

MATERIALS AND METHODS

Herbicide treatments for the preemergence and postemergence control of browntop panicum were evaluated in CP 61-37 sugarcane on silty clay loam near Mathews, Louisiana. Commercial formulations of herbicides were applied in water at 40 gal/A to plots 3 beds wide (18 ft) by 45 ft long. The experimental design in each experiment was a randomized complete block with 3 or 6 replications for primary evaluation studies and 6 replications for secondary evaluation studies.

Primary evaluation studies were conducted in duplicate experiments during 1973 and 1974. The herbicides terbacil at 1.6 and 3.2 lb/A; fenac at 1, 2, and 4 lb/A; trifluralin at 2 lb/A (incorporated into soil with a rolling cultivator in one experiment and covered with 0.5 in. of soil to simulate incorporation in the other); metribuzin at 2 lb/A; and tebuthiuron at 2 lb/A were applied in March in a 36-in. band over the sugarcane drill. Weed control was rated in late May.

Secondary evaluation studies for preemergence control were conducted in duplicate experiments in 2nd- and 3rd-ratoon sugarcane during 1975 and 1976. Fenac at 1.8 or 4.5 lb/A or a mixture of fenac at 1.8 lb/A and terbacil at 2.4 lb/A were applied in a 30-in. band over the sugarcane drill on top of the bed in March. The sides of the bed were cultivated as needed to control weeds. In some plots, fenac at 1.8 lb/A was applied broadcast to the bed and water furrow after the last cultivation (lay-by) in May. Weed control was rated in late May before lay-by and in late July. Sugarcane plots were harvested mechanically in October and weighed. A 20-stalk sample from each plot was crushed in a sugarcane-sample mill to extract the juice, and the juice was analyzed by polarimetry for its sucrose content. We used yield of cane and sugar as a quantitative measure of the efficiency of treatments in controlling browntop panicum.

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[1] A contribution from ARS, USDA in cooperation with the Louisiana Agricultural Experiment Station.

Primary evaluation studies for postemergence control were conducted in 1 experiment during 1974. The herbicides asulam at 3 and 4 lb/A, dalapon at 2.3 and 3.4 lb/A, MSMA at 2 lb/A, and ametryn at 2.5 and 3.5 lb/A were applied on May 13 over browntop panicum 10 to 12 in. tall growing on the sides of sugarcane beds. A commercially blended nonionic surfactant--mixture of alkylaryl polyoxyethylene glycols, free fatty acids, and isopropanol--was added to water-herbicide mixtures at 0.25% v/v for asulam, dalapon, and MSMA and at 0.5% v/v for ametryn. Browntop panicum control was rated 60 days after treatment.

RESULTS AND DISCUSSION

As anticipated, terbacil did not provide effective preemergence control of browntop panicum (Table 1). Metribuzin and tebuthiuron, other herbicides that also kill weeds by inhibiting photosynthesis, also did not control browntop panicum effectively. Trifluralin gave 74% control, and fenac at 1, 2, and 4 lb/A gave 74%, 99%, and 100% control, respectively. Fenac was the most effective herbicide tested.

Table 1. Control of browntop panicum with herbicides applied to soil before seedling emergence.

Herbicide	(lb/A)	% control
Terbacil	1.6	9
Terbacil	3.2	29
Metribuzin	2.0	35
Tebuthiuron	2.0	49
Trifluralin[1]	2.0	74
Fenac	1.0	74
Fenac	2.0	99
Fenac	4.0	100

[1] Incorporated into soil at application.

In the secondary evaluation studies in ratoon sugarcane, heavy browntop panicum infestations did not develop on the sugarcane drill in the spring as shown by the 75% area that was free of panicum in the untreated check (Table 2). The soil on top of the bed is essentially untilled and becomes hard-packed in the ratoon crops. Such soil probably did not provide a suitable seed bed for germination because browntop panicum seed germinated profusely on the cultivated sides of beds. Seed did germinate on top of the bed after lay-by, probably because soil was thrown there during the lay-by cultivation.

Table 2. Control of browntop panicum and yield of CP 61-37 sugarcane as influenced by fenac treatments (average of 2 experiments).

Herbicide treatment[1]		% of area free of panicum		Sugarcane Yield[2]		
Spring (lb/A)	Lay-by (lb/A)	On drill before lay-by	Whole row after lay-by	Cane/A (ton)	Sugar/ton of cane (lb)	Sugar/A (lb)
Fenac - 1.8	+ None	95	0	31 bc	175 a	5429 a
Fenac - 1.8	+ Fenac - 1.8	95	100	32 c	175 a	5666 a
Fenac - 4.5	+ None	98	0	31 bc	176 a	5459 a
Fenac - 4.5	+ Fenac - 1.8	95	100	32 c	170 a	5451 a
(Fenac - 1.8 + terbacil -2.4)	+ None	95	0	30 ab	174 a	5292 a
(Fenac - 1.8 + terbacil -2.4)	+ Fenac - 1.8	95	100	31 bc	174 a	5388 a
Hand-weeded	+ None	100	0	31 bc	171 a	5364 a
Hand-weeded	+ Hand-weeded	100	100	31 bc	177 a	5469 a
Untreated	+ Untreated	75	0	29 a	175 a	5108 a

[1] Herbicides applied on a 30-inch band in spring and broadcast at lay-by.
[2] Means followed by the same letter are not significantly different at the 5% level of probability as determined by the Duncan's multiple range test.

The browntop panicum infestation in the untreated check reduced yield of cane/A below that of most herbicide treatments and the hand-weeded checks (Table 2). However, the decrease was only about 6%, and the yields of sugar/ton of cane and sugar/A were not significantly different from other treatments. The average yield of 31 tons/A for all treatments in the study was higher than that expected from 2nd- and 3rd-ratoon sugarcane that had been infested with browntop panicum from the time of planting. Such a relationship shows that browntop panicum is only moderately competitive with a relatively vigorous sugarcane cultivar such as CP 61-37, and not in the same class as johnsongrass or itchgrass which in a similar period of time severely reduces stands and yield of sugarcane (5, 6). Browntop panicum doubtless would have been more competitive and reduced yields more if heavy infestations had developed on the sugarcane drill in early spring when sugarcane was becoming established.

Browntop panicum was controlled almost perfectly during the growing season by spring and lay-by applications of fenac at 1.8 lb/A either applied alone or in a mixture with terbacil (Table 2). Fenac at 3.6 to 4.5 lb/A controls johnsongrass from seed but fenac at 1.8 lb/A probably would not provide effective control in combined johnsongrass and browntop panicum infestations unless mixed with terbacil.

Dalapon, MSMA, and ametryn provided effective postemergence control of 10- to 12-in browntop panicum but asulam was not effective (Table 3). I observed that asulam killed 3-in. plants but only stunted the larger ones. Other research has shown that asulam will control large browntop panicum if applied in a mixture with ioxynil (4-hydroxy-3,5-diiodobenzonitrile), 2,4-D [2,4-dichlorophenoxy) acetic acid], and a nonionic surfactant (1).

Table 3. Control of browntop panicum about 12-in tall with herbicides applied to the foliage.

Herbicide[1/] (lb/A)	% control
Asulam - 3.0	15
Asulam - 4.0	20
Dalapon - 2.3	92
Dalapon - 3.4	97
MSMA - 2.0	98
Ametryn - 2.5	90
Ametryn - 3.5	100

[1/] Mixed with a nonionic surfactant.

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THE SUSCEPTIBILITY OF FLORIDA SUGARCANE RATS TO DIPHACINONE

R. C. Ostrowski[1], R. E. Nease[1], and R. L. Lipsey[2]

ABSTRACT

The three rat species prominent in Florida sugarcane damage were cage tested to determine their acceptance to and mortality from the consumption of a pelleted bait. The Cotton (Sigmodon sp.), Roof (R. rattus) and Rice (Oryzomys sp.) rats were susceptible to poisoning by the anticoagulant Diphacinone when it was presented in a commercial pellet RAMIK. The Environmental Protection Agency standards of 30 percent acceptance and 90 percent mortality were surpassed by all three species when they were exposed to the choice of the pellet or a challenge bait. Preliminary field evaluations of a commercial aerial application of these rodenticide pellets in the ditch-bank areas indicate that the application technique and material show promise as a rat-control method.

INTRODUCTION

Sugarcane losses from rat damage were estimated for the 1969-70 Florida crop at one million dollars (Samol). Current estimates are not available; however, old estimates should at least be inflated to embrace present costs and values. The four rat species that are known to damage Florida sugarcane are: the cotton rat, Sigmodon hispidus; the rice rat, Oryzomys palustris; the roof rat, Rattus rattus, and the Florida water rat, Neofiber alleni. The cotton and roof rats are the predominant species.

While much is to be learned regarding the habits and population dynamics of these pests, the following generalizations seem valid. The Florida rat (Everglades water rat, round-tailed muskrat) apparently spends considerable time below the ground line; a probable romance with the lake and irrigation water table. While their colony-like burrows can be found in the ditchbank area, it is more usual to recognize their presence by a cleared circular area within the cane field as a result of cane death through root pruning and crown damage. Obviously, the subterranean habits of this pest should render ineffective any surface broadcast application of a rodenticide. The roof, cotton, and rice rats are known to inhabit the ditchbank areas and forage into the cane field under the cover of darkness when the cane has attained sufficient size and sugar content. In the field, burrowing may occur and excavation of vacated tunnels of predecessors. Major food sources, however, are known to be in the ditchbank area.

MATERIALS AND METHODS[3]

RAMIK® Rodenticide[4] is a grain based extruded pellet that exhibits the degree of weatherability necessary for its candidacy as an outdoor broadcast material. It's active ingredient, diphacinone, is incorporated at 0.005% (50 ppm).

Full EPA protocols for standard laboratory evaluation were conducted on the three ditchbank inhabiting rat species, roof, cotton, and rice rats.

Standard EPA protocols require 90% or greater animal mortality and at least 33% acceptance of the test bait over a standard challenge bait whose positions are alternated daily in the cage. Wild rats, 10 male and 10 female of each species, were acclimatized by a 10-day holding period and fed test bait for a miximum of 15 days. A control group was maintained throughout the test period. This group had a 100% survival rate. Evaluation results are based on product performance against the grouped data averages.

Population counts before and after commercial aerial application were also conducted in 1975 on ditchbank areas surrounding the sugarcane fields.

RESULTS

Cage. The RAMIK® Rodenticide Green pellet (fish flavored) was used primarily in all tests. The roof rat (Table 1) attained 90% mortality in about 9 days. Some rats died on the 3rd and 4th day with an average of about 7 days for the group.

Only 7 rice rats had been trapped during the test period at the Belle Glade Agriculture Research Center. However, there was 71% acceptance, 90% mortality was reached in 8.3 days, and the average number of days to death was 6. There is no question that the duplication of these results for a full protocol test will be easily attained.

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[1] Velsicol Chemical Corporation.

[2] Now Pesticide Coordinator, University of Florida, Gainesville.

[3] The excellent cooperation of the Florida Sugarcane League, Dr. J. R. Orsenigo, Director of Research, and the University of Florida, Belle Glade Agr. Research Center, Dr. D. L. Myhre, Director, are gratefully acknowledged.

[4] RAMIK Rodenticide is a registered trademark of the Velsicol Chemical Corporation.

Table 1. Results with the roof rats from experiments with Ramik Green.

Sex	No.	Acceptance* (%)	90% mortality (days)	Ave. death (days)
M	10	32	9	6.8
F	10	38.6	8.6	6.7

*Versus challenge bait.

As indicated in Table 2, the cotton rat readily consumes the RAMIK® Rodenticide Green pellet. These excellent data indicate that a 4-5 day feeding period will result in the minimum 90% mortality in 7 days with an average death within the group in 6 days. RAMIK® Rodenticide Brown, apple flavored, did almost as well (Table 3).

Table 2. Results with the cotton rat from experiments with Ramik Green.

Sex	No.	Acceptance* (%)	90% mortality (days)	Ave. death (days)
M	9	86.5	7	6.0
F	11	81.4	7	6.0

*Versus challenge bait.

Table 3. Results with the cotton rat from experiments with Ramik Brown.

Sex	No.	Acceptance* (%)	90% mortality (days)	Ave. death (days)
M	10	50.7	9	6.3
F	10	65.0	8	6.3

*Versus challenge bait.

Field. Preliminary field observations were made in 2 plantation locations where commercial aerial applications were used to cover the ditchbank areas. Pretreatment counts (the 2 nights preceding application) were made with live traps to ascertain 1) if population size warranted treatment, 2) species and their ratios, and 3) population imbalances between treatment and check areas.

Traps were baited with fresh apple wedges covered with peanut butter. One week after treatment rat traps were again set for 2 nights.

Overall, a 55% pretreatment trap occupancy was obtained. In location A a 62.5% occupancy was reduced after treatment to 21%, netting a 66.5% reduction in population.

In location B where a post-treatment check area was maintained, the high trap occupancy did not diminish, showing the good correlation in treatment effect where a 62.0% reduction in population occurred.

BAGASSE CONVEYING

William M. Jacobsz Rosier
Rio Grande Valley Sugar Growers
Santa Rosa, Texas

ABSTRACT

Instead of the conventional way of transporting bagasse from the mills to the boilers with slat-type carriers and dumping excess bagasse in the bagasse room, the factory transports bagasse straight from the mills to the bagasse room with one slat conveyor and two five-foot-wide rubber-belt conveyors. About 60 to 80 percent of this bagasse is dumped in a pit, from which a slat-type conveyor system supplies the bagasse to the boilers. Any excess bagasse from this system is returned to the bagasse house. The remaining 20 to 40 percent of the bagasse on the rubber belt conveyor is stored in the bagasse house from which two payloaders also supply the pit of the slat carrier. This system has not worked satisfactorily yet because there have been extensive break-downs on the slat carriers.

The major problem has been the carrier supply to the boilers. The carrier is designed in such a way that it has two decks and, thus, carries full loads going in both directions: the upper deck, to transport the bagasse to the other end of the carrier; and the lower deck, to supply the bagasse feeders of the two Riley and the two Bigelow boilers. The belt conveyors are not experiencing trouble, except that they plug up, from time to time, mainly due to high cane fiber, high bagasse moisture, or full bagasse house (plugged up chutes on the belt).

The ploughs, which regulate the amount of bagasse to the return conveyor, do not work as they should, yet. During start-ups or mill stops, three front-end loaders in the bagasse house keep the pit full and, thus, insure a steady bagasse supply to the boilers. Specific operational experiences are described. A complete reconditioning of the bagasse-feeder conveyor is on the firm's program for this "off season," as well as extensive repairs and modifications of the other conveyors to ensure a better service for next crop.

Last year we introduced a new feature in the bagasse conveying system in the fire room of the Rio Grande Valley Sugar Grower's Plant, in Santa Rosa, Texas. Instead of the conventional way of transporting bagasse from the mills to the boilers with slat type carriers and dumping excess bagasse in the bagasse room, we transport our bagasse straight from the mills to the bagasse room with one slat conveyor and two 5-foot-wide rubber belt conveyors, (B.C. 1, 2, and 3). About 60-80% of this bagasse is dumped in a pit from which a slat type conveyor system (B.C. 4, 5, and 6) supplies the bagasse to the boilers. Any excess bagasse from this system is returned to the bagasse house. The remaining 20-40% of the bagasse on the rubber belt conveyor, B.C. 3, is stored in the bagasse house from which two payloaders also supply the pit of the slat carrier, B.C. 4. This system has not worked satisfactorily yet, as we have experienced extensive break-downs on the slat carriers.

The major problem has been the carrier supplying the boilers, B.C. 6. This carrier is designed in such a way that it has two decks and thus carries full loads going in both directions, the upper deck to transport the bagasse to the other end of the carrier and the lower deck to supply the bagasse feeders of the two Riley and the two Bigelow boilers.

This double load has caused tremendous strains on the carrier, resulting in worn carrier chains and sprockets, broken tail shafts and bearings, and plenty of headaches and nightmares as well as downtime overtime for repairs and high material and labor costs.

Also, the return carrier in the pit, B.C. 4, has its bugs as it is not possible to check the tail shaft in the pit and to lubricate the bearings during operation. Spillage of bagasse and dust covers the tail-end assembly completely, making it necessary to dig everything out during scheduled stops.

Tramp iron and broken slats were other causes of concern. They broke slats in this carrier and were the cause of a broken tail shaft bearing and consequently broken carrier chains on one occasion. Tramp iron caused the carrier chain to jump the sprockets on another occasion.

The belt conveyor, B.C. 2 and B.C. 3, are not giving us any trouble whatsoever, except that they plug up once in a while, mainly due to high cane fiber, high bagasse moisture, or full bagasse house (plugged up chutes on the belt).

The plough, which regulates the amount of bagasse to the return conveyor, does not work yet as it should. The plough is supposed to open automatically when bagasse piles up in front of it and close after the pile moves on. A counter-weight on a cable holds the plough in place. There is also a pin-device made of a 2" steel pipe which is adjustable to regulate the smaller or greater opening of the plough which in turn gives more or less bagasse to the return conveyor. We are not able to properly regulate the bagasse flow, though, and are still experimenting with different set-ups in this system.

During start-ups or mill stops three front-end loaders in the bagasse house keep the pit full and thus insure a steady bagasse supply to the boilers. This, as one can see, is rather difficult as the loaders are either overloading or underloading the carriers and they also have to be taken out of service regularly due to plugged-up radiators, air filters, overheating engines, leaking hydraulics, etc.

We have a complete reconditioning of the bagasse feeder conveyor, B.C. 6, on our program for this off season as well as extensive repairs and modifications of the other conveyors to ensure a better service for the next crop.

PRE-DRYING BAGASSE USING FLUE GASES

J. H. Farines
Atlantic Sugar Assoc.
Belle Glade, Florida

ABSTRACT

Data obtained during the 1975-76 grinding season at Atlantic Sugar factory with pre-dryer bagasse using flue gases lead to general conclusions of fuel savings as a result of an improved value of bagasse.

It is indeed a pleasure to present to you a subject that is or should be of utmost interest to all those in the cane sugar industry: Lowering moisture content in bagasse to improve it as a fuel. I am sure that most of the engineers handling cane sugar factories have given some thought to this problem.

I spent my first 17 professional years in Cuba's sugar industry. During that time I worked or visited more than 100 factories, and it can be safely stated that burning oil or any other auxiliary fuel in any of them was considered a sin. Developing the proper steam balance was a major task in our responsibilities, and it was easily attainable. We all know that bagasse moisture in Cuban mills was always in the range of 47 to 48%, mainly because of very clean cane and relatively low grinding speed. Facing this fact was hard at the beginning, but eventually we learned to live with it because any project to extract more moisture from bagasse was not economically sound.

Louisiana, because of harvesting characteristics, averages moisture from 49 to 52% and more in some cases. Florida, because of higher speeds, and the presence of muck during harvesting, has a moisture content of 52 to 56%.

During the fuel-crisis of 1972-73, we were asked by Atlantic Sugar Association to prepare a feasibility study to pre-dry bagasse with waste stack gases. Under present conditions, the sugarcane bagasse leaving the milling tandem at Atlantic has relatively high moisture content, in the order of 53 to 55%. Bagasse constitutes a reasonably good waste fuel as long as its moisture content is around 50% or lower. However, as the moisture content of the bagasse increases its heating value is reduced and boiler efficiency substantially curtailed.

During our study we contacted different manufacturers of equipment designed to dry refuse similar to bagasse. We were highly impressed by the equipment for drying bagasse at the basse pelleting plant at Clewiston, Fla. The manufacturers of this dryer (Vincent Processes of Tampa), indicated their capability of designing the proper units and willingness to guarantee their performance.

Vincent Processes furnished prices for a 3 rotary-drum type dryers of maximum capacity to operate with existing boilers based on flue gases temperature of 425 F. According to Vincent Processes, these 3 dryers could handle all the bagasse produced by a daily grinding rate of 8000 tons of cane and lower the moisture content from 54% to 46%, provided the gases had a temperature of 425 F or more.

We designed the system of diverting the bagasse to go to the dryers and returning to be fed to the boilers with the original installation. Similarly, the gases were by-passed to go to the dryers and back to the I.D. fan and stack. The results of our report was that the fuel consumption at Atlantic Sugar could be dropped from around 1.6 gal per ton of cane for the last 2 years to about .5, and maybe as low as .25. Saving of only 1 gal per ton in a grinding season of 900,000 tons at todays price of over 30 cents per gallon is a saving of at least $270,000. Considering maintenance and repair it is safe to predict a payback of 5 years on the required investment.

The project was approved and last grinding season Atlantic Sugar started the first commercial bagasse dryers using stack flue gases. As is usually the case on a new installation, we encountered many problems, some expected, some not. These included the following:

1) The rainy season delayed the final installation.
2) The valves to by-pass the flue gases were of poor quality and did not operate to expectation. New valves had to be re-designed and prepared to be installed during the Christmas shutdown. However, the original valves could be operated enough to run tests of 8 to 10 hours on one boiler, obtaining very satisfactory results, proving we were on the right track. The by-passing of the bagasse worked so well that it never caused one minute of lost time. Once the new by-pass valves were installed during Christmas shutdown we were able to operate two boiler-dryers on a continuous basis for many days at a time.
3) Another major problem which developed from the beginning was that the I.D. fan of one of the boilers did not develop the required pressure drop, and therefore was not able to operate all season. The other two were continuously troubled by the testing of the also newly installed wet scrubbers.

4) We were very concerned about possible air leaks in the system, especially at the inlet of the bagasse discharge. However, the results indicated that this type of problem was very insignificant.
5) The discharge valve did give a lot of trouble, but it was finally overcome, and its performance was very satisfactory afterwards.
6) There were chocking problems on the feeder and discharge screws, the first mainly because of tramp iron entering with the bagasse, the latter due to poor workmanship of the scroll and bearings as well as the already mentioned discharge valve. All of these problems were corrected, and the equipment eventually worked smoothly.
7) During the first few days of operation we had a fire in one dryer, but the only cause was the already mentioned discharge screw chokes, combined with the poor operation of the by-pass flue gas valves. The bagasse feed had to be shut down, and hot gases kept circulating through the dryer, lowering the moisture content of the bagasse in the system to self-ignition point. We installed low pressure steam access to each dryer to prevent future problems, but never really had to use it.
8) Once the operation was continuous, the prevailing winds blew away the best fine dry particles. Proper covers and dampers diminished this problem tremendously.

One unexpected asset to the system was that during small mill stops like chokes or empty runs the boilers were not affected because the bagasse kept coming from the dryers, which have a retaining effect of 10 to 15 minutes.

Since we have a limited time, I would like to present in chronological order the performance and operation of the dryers:

Nov. 19 to Dec. 26: One unit-non operative because of fan capacity; two units limited because of damper operations. This period was used to correct other problems and make a lot of experimental runs, correction of the discharge valve arrangement, improvement on feed and discharge screws, installation of safety devices in case of fires, and generally doing day-by-day observations which gave us the necessary experience for controls and operation guidance.

Dec. 26 to Jan 2nd: During the holiday shutdown of Dec. 24th and 25th the by-pass flue gas valves were changed for the newly built ones. From start up again on Dec. 26 to Jan 2nd, we made a few short runs and got the new dampers to operate with ease.

Jan 3rd to Feb. 25: On Jan 3rd we were able to obtain perfection, having run for 24 hours not using any auxiliary fuel. From then on, we had many days of insignificant fuel consumption readings like 400, 700, 500, etc. which is .05 gal/ton or less. However, during this period we were confronted with problems in passing the compliance tests of the different boiler with the newly installed wet scrubbers, and the use of the dryers was not 100% because the tests were required without the dryers. In spite of this handicap, and only having 2 dryers in operation, the oil consumption during this period was .588 gal/ton of cane ground.

Feb. 25 to end of grinding: From Feb. 25 to March 4th, an unusual rainy season disrupted grinding, and it was difficult to operate the dryers because of continuous shutdown and startup.

Even with all the hardships of the first year of operation, the total fuel oil consumption of 1976 was 1.01 gal per ton of cane compared with an average of 1.62 during the previous two years, showing an average saving of .61 gal/ton of cane. For 1976 the grinding of 892,032 tons of cane showed a savings of 892,032 x .61 = 544,140 gal of bunker oil, which at the price of 32 cents per gallon represents a total saving of $174,125.

Now that the first year has gone by and most of the problems overcome, we feel that a projection of .3 gal/ton of cane for 1976-77 is conservative and close to our original forecast. We also feel that saving fuel by the proper drying of bagasse provides not only money savings but also self-sufficiency in case of another fuel crisis.

We would like to show a short movie which will give a general idea of the installation and operation of the bagasse-dryers here in described.

Restriction of time for this subject has prevented us from giving more details but we will be glad to answer any questions now or privately after the meeting.

THE IMPACT OF WASTE-FUEL DRYING ON BOILER OPERATION, INCLUDING FUTURE BOILER DESIGN

William P. Boulet
New Orleans, Louisiana

ABSTRACT

Technical factors which impact boiler ability to use waste fuel efficiently have been evaluated for more than 60 years. The volumetric efficiency in boiler-furnace operation and how it affects thermal efficiency and optimum performance vary with varying mill conditions. The effect of waste-fuel drying is compared with other methods of increasing boiler efficiency and performance. The effect of fuel drying on existing boiler efficiency under various conditions at existing mills is discussed, along with the maintenance of steam balance under fuel surpluses. The implications of the foregoing on future boiler design and purchase are evaluated.

DIFFERENT APPROACHES TO MEETING STEAM REQUIREMENTS IN A SUGAR HOUSE

Blas M. Rodriguez and Augusto M. Blanchard
United States Sugar Corporation
Clewiston, Florida

ABSTRACT

Frequently, a sugar house is faced with either a shortage of low pressure steam needed to efficiently perform its boiling house operation, a lack of live steam required to expand the capacity of the main movers, or a combination of both. In order to meet these situations with economic advantages, the following approaches are described: The use of thermocompressors to supplement the exhaust steam, instead of the make-up with live steam through pressure reducing devices. The utilization of suitable heat exchangers to recover the sensible heat in excess condensate waters to partially replace the vapors or exhaust steam used to bring raw cane juice up to the boiling point. The operation of vacuum pans with low pressure vapors from second effect evaporators to accomplish further savings of steam.

INTRODUCTION

With the rising cost of process steam in a sugar factory, for fuel as well as for generating equipment, and at a time when new and profitable uses are being found for bagasse, it becomes highly important to strive for an increased steam economy.

As a result of the implementation of known techniques, grinding capacity can be increased without the high capital expenditures for additional steam boilers, and/or the need for supplemental fuel can be reduced.

Before illustrating the savings in process steam accomplished at Bryant Sugar House with comparative steam balances, we will briefly describe approaches we have taken in order to successfully meet steam requirements while increasing our grinding capacity to up to 14,000 tons of cane per day.

APPROACHES AND DISCUSSION

Thermocompression.

When the amount of exhaust steam available for the boiling house has to be supplemented by live steam, as is the case in a well designed efficiently operated sugar house, the use of thermocompression can result in live steam economy or an increase in evaporation capability.

The high pressure live steam, as it passes through the driving nozzle of a thermocompressor, creates a jet action that sucks in vapors from the interconnected evaporation system. The energy transferred to the vapors from the live steam in the diffuser of the thermocompressor results in an increase in temperature and pressure that will make it possible for the aspirated vapors to create evaporation in the juice that it came from. Thus, the steam savings can be considered equal to the installation of an extra stage whose evaporating capacity is to the extent of the vapors recompresed.

The thermocompressors station at Bryant Sugar House consists of five units of two different sizes for flexibility purposes. These units compress first evaporation vapors from 12 psig at 244 F to the exhaust header at 22 psig, the motive fluid being live steam at 360 psig. The entrainment ratio of the thermocompressors is 1.33. The number of units kept in operation depends on the exhaust steam requirements for the boiling house and the availability of live steam.

Heat Exchanging.

In order to bring the raw cane juice to just above its boiling point, from 250,000 to 275,000 B.T.U.'s per ton of cane ground are needed in a sugar house. The heating energy is usually obtained from juice vapors bled from the evaporation system or from exhaust steam.

In a modern sugar factory, when an efficient use of steam for juice evaporation and sugar boiling has been accomplished, an excess amount of condensate waters develops, which is usually ditched. These condensate waters recovered in properly sealed, well insulated tanks are of good heating characteristics. By incorporating suitable liquid-to-liquid heat exchangers into the juice heating system, the sensible heat in condensate waters can be recovered to a great extent at the first stage of the juice heating.

At Bryant Sugar House, two units of 2,800 square feet of heating surface each are utilized. The temperature of the raw cane juice is raised from 80-85 F to 145-150 F, or to about half of the heating requirement. Approximately 1,500 gallons of water per minute at about 225 F are pumped through these two heat exchangers. This is all of the condensate waters from the vacuum pans, juice heaters and evaporators with the exception of exhaust steam condensation from first effect evaporators, which is used as boilers feedwater. The balance of our juice heating requirements is obtained by using low pressure vapors bled from second effect evaporators at 3-5 psig.

Operation of Vacuum Pans with Low Pressure Vapors.

Boiling sugar with vapors from pre-evaporators or first effect evaporators is a practice that has been carried out for its steam economy throughout the sugar industry for many years.

In more recent times, the use of steam and/or mechanical circulators in vacuum pans is finding widespread acceptance, since a more rapid, uniform crystal growth is accomplished with the improved massecuite circulation. Furthermore, technical advances in the field of instrumentation, and their adoption in sugar factories, are making it possible to obtain a more continuous, better controlled feed of syrup and molasses. As a result, not only the sugar boiling technique is improved and simplified, but a uniformity in the demand from the energy source is obtained for the operation of vacuum pans.

Vacuum pans of improved design, equipped and operated under the conditions outlined above, can perform very satisfactorily with vapors at much lower pressures than normally used in most sugar mills.

At Bryant Sugar House, the installation of a vapor cell of 18,000 square feet of heating surface, supplying vapors at 2-5 psig to the vacuum pans station, and being fed with vapors from our first evaporation at 12 psig, has resulted in an extra evaporation being obtained without increasing the boiling house heating energy requirements.

In order to obtain an efficient performance from our vacuum pans at such low vapor pressures, the following steps have been taken:

1. Yearly cleaning of the vapor side of the vacuum pan tubes to assure the maximum heat transfer.
2. Installation of additional gas vents in the vacuum pans.
3. Installation of mechanical circulators in the vacuum pans.
4. Improved feed of syrup and molasses with the injection of steam.
5. Continuous automatic feed.
6. A comprehensive program to balance the steam requirements, avoiding extreme peak demands.

THEORY

To theoretically demonstrate what in actual operation we have achieved with the practice of the approaches we have described, two different evaporating schemes have been worked out.

Case I (Fig. 1) - Quadruple effect evaporation with vapor bleeding from the first effects for the vacuum pans and juice heaters. The exhaust steam is supplemented by live steam through a pressure reducing valve.

Case II (Fig. 2) - Quadruple effect evaporation with the vacuum pans being fed with low pressure vapors from a vapor cell. The juice is heated with condensate waters and second effect vapors. Exhaust make-up is by means of thermocompressors.

Comparative Data

	Case I	Case II
Cane ground, tons per day	10,000	14,000
Raw juice - extraction	100%	100%
lb/hr	833,300	1,167,000
brix	14.0	14.0
temperature	80 F	80 F
Clarified juice temperature	205 F	205 F
Evaporation	78.0%	77.6%
Syrup - pounds	182,690	261,700
brix	63.8	62.4
Vacuum pans - assumed steam required	16.8% cane	16.8% cane
lb/hr	140,000	196,000
Exhaust steam	322,000	322,000
Live steam make-up	58,000	58,000

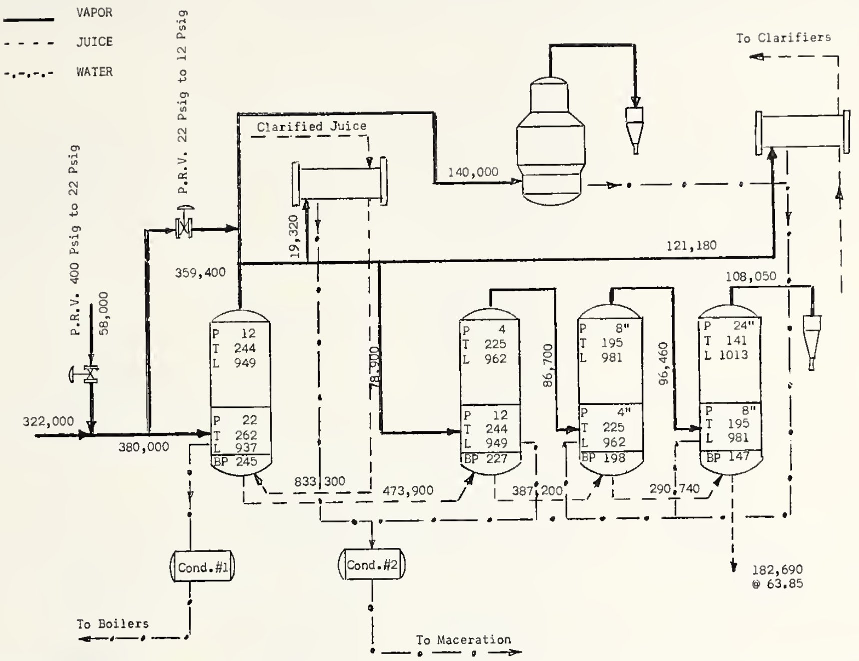

Figure 1. Quadruple effect evaporation with vapor bleeding from the first effects for vacuum pans and juice heaters.

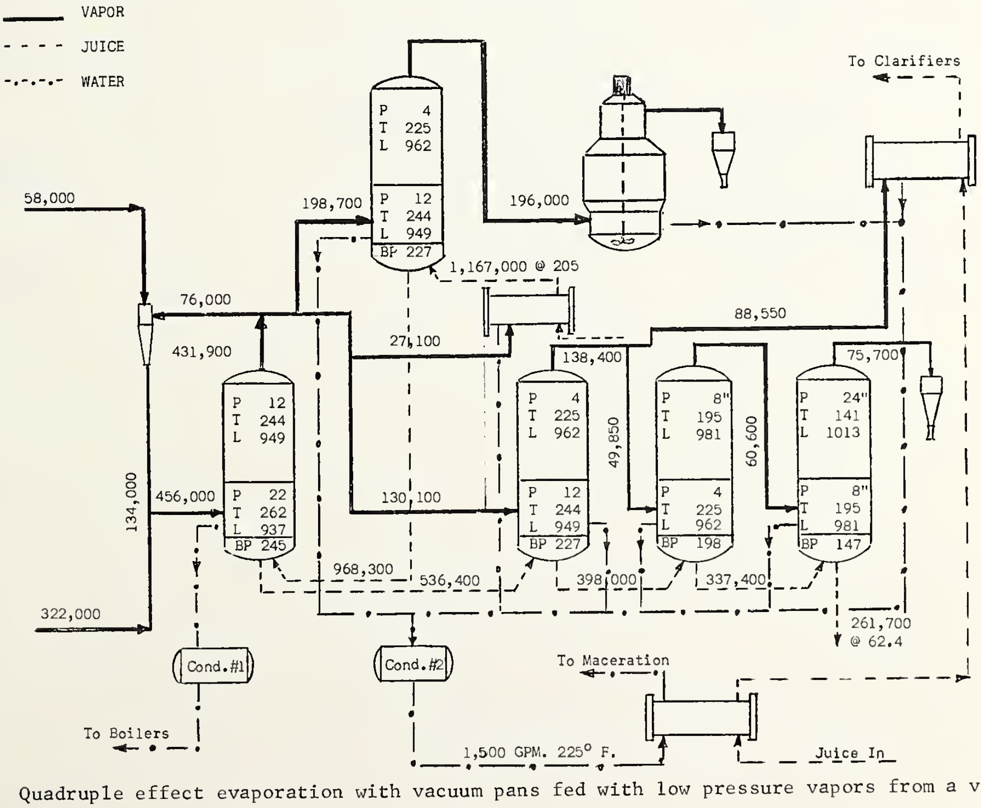

Figure 2. Quadruple effect evaporation with vacuum pans fed with low pressure vapors from a vapor cell.

For the last 11 crops, our live steam production has been obtained from the same three Riley-Stoker steam boilers with a rated capacity of 120,000 lb/hr per boiler at 400 psig, 550 F superheat, with two hours peak capacity of 132,000 lb/hr per boiler. However, during the 1975-76 crop, our average steam production was 140,000 lb/hr per boiler with peaks of 160,000 lb/hr per boiler. Two of the things that have allowed us to obtain this type of performance from our boilers are our low moisture in bagasse and the fact that our condensation from exhaust steam with the resulting makeup from thermocompression gives good quality, hot boiler feedwater. Thus, for our calculations, we have assumed an average loss of 10%, leaving 380,000 lb/hr available for boiling house steam requirements.

CONCLUSION

In conclusion, we must remind you that the more involved the plan for steam economy, the more complex the setup connecting these various pieces of equipment will be. It then becomes increasingly important to pay careful attention to your operations, as your flexibility is inversely proportionate to your overall complexity. This in turn creates more and more of a dependence on instrumentation, and automation eventually becomes a must.

CASE I - CALCULATIONS

	B.T.U.	Lb of steam	Liquor
First Effect Evaporators -			
Exhaust steam in - 380,000 (262 F.) x 937	356,060,000	380,000	833,300 (brix 14.0) (temp. 227 F.)
Deduct for heat to boiling pt. - 833,300 (245-227)	- 15,000,000		
Available for evaporation -	341,060,000		
Evaporation - 341,060,000/949		359,400	-359,400
To raw juice heaters - 833,300 (218-80)	115,000,000	121,180	
To clarified juice heaters - 833,300 (227-205)	18,334,000	19,320	
To vacuum pans - 10,000 x 16.8%	132,860,000	140,000	
To second effect evaporators -	74,866,000	78,900	473,900 (brix 24.6)
Flash - 473,900 (245-227)	8,530,200		
Available for evaporation -	83,396,200		
Evaporation - 83,396,200/962		86,700	- 86,700
To third effect evaporators -	83,396,900		387,200 (brix 30.1)
Flash - 387,200 (227-198)	11,229,000		
Available for evaporation -	94,625,900		
Evaporation - 94,625,900/981		96,460	- 96,460
To fourth effect evaporators -	94,625,900		290,740 (brix 40.1)
Flash - 290,740 (198-147)	14,828,000		
Available for evaporation -	109,455,100		
Evaporation - 109,455,100/1,013		108,050	-108,050
To syrup tanks -			182,690 (brix 63.8)

CASE II - CALCULATIONS

	B.T.U.	Lb of steam	Liquor
Pans vapor cell (1-18,000 sq. ft. h.s.)			1,167,000
			(brix 14.0)
Evaporation - 188,566,000/949			- 198,700
Exhaust steam in - 456,000 x 937	427,272,000		968,300
			(brix 16.9)
Deduct, juice from v.c. to boiling pt. 968,300 (245-227)	- 17,429,400		
Available for evaporation	409,842,600		
Evaporation - 409,842,600/949		431,900	- 431,900
To clarified juice heaters (3) 1,167,000 (227-205)	25,674,000	27,050	
For thermocompressors (2) 76,000 (949)	72,124,000	76,000	
For pans vapor cell (1) 198,700 (949)	188,566,000	198,700	
For second effect evaporators (2)	123,478,600	130,150	536,400
			(brix 30.4)
Flash - 536,400 (245-227)	9,655,200		
Available for evaporation -	133,133,800		
Evaporation - 133,133,800/962		138,400	- 138,400
For second stage juice heating 1,167,000 (218-145)	85,191,000	88,550	
To third effect evaporators	47,942,800		398,000
			(brix 41.1)
Flash - 398,000 (227-198)	11,542,000		
Available for evaporation -	59,484,800		
Evaporation - 59,484,800/981		60,600	- 60,600
To fourth effect evaporators -	59,484,800		337,400
			(brix 48.4)
Flash - 337,400 (198-147)	17,207,400		
Available for evaporation -	76,692,200		
Evaporation - 76,692,200/1,013		75,700	- 75,700
To syrup tanks -			261,700
			(brix 62.4)

COMPROMISE BOILING SYSTEM

Carlos R. Toca
Carlos R. Toca, Inc.
New Iberia, Louisiana

ABSTRACT

Equipment requirements, pan-boiling procedures and results of experience with a compromised boiling system in Florida and in Louisiana are compared with conventional boiling systems.

INTRODUCTION

The intention in publishing our experiences with this boiling system that we classify as a compromise between our classic Three Boiling System and Three and One Half Boiling System and some new revolutionary systems established in some sugar factories is to inform our fellow technicians of our experiences, conclusions, and perhaps some recommendations about this system that we consider of great value.

BOILING SCHEME

This system consists mainly of boiling the B strike out of a C sugar magma footing with A molasses, and using the B sugar resulting from this strike for magma as footing for A strikes.

All the commercial sugar produced is from A strikes, either straight A massecuite boiled totally with syrup or occasionally a top-off A boiled with syrup and finished with A molasses resulting from a straight A massecuite.

Graining is done on pure syrup or a blend of syrup and straight A molasses depending on the purities; we try to granulate on a purity of 76 to 78.

ADDITIONAL EQUIPMENT REQUIRED

This boiling system needs some additional equipment, as follows:

a) An extra magma seeder for B sugar magma. We handle two types of magma, the regular C sugar magma that is used for B strikes footing and the B sugar magma resulting from the curing of B strikes and used for A strikes footing.

b) Additional centrifugals for B sugar separated from the commercial sugar (A sugar) equipment. This operation could be done either on regular batch machines or continuous centrifugals. Both the high grade or the low grade type continuous centrifugals are suitable for this operation.

c) Additional magma pump and mingler for B sugar magma.

d) B molasses pump separated from A molasses have to be provided.

This system was implemented at Osceola Sugar Factory in Florida with the sole idea of making high test sugar, over 99.0 pol, with a minimum effort. The results as per the quality of sugar were excellent as can easily be understood since all the commercial sugar produced is resulting from A strikes, with additional advantages that these strikes are boiled using a very good footing from B sugar magma.

Osceola factory was not fully equipped at least until last year, to carry out this system all the time, so, it was limited to the high test sugar production.

Our main problem at Osceola was that by not having sufficient capacity in magma receivers C and B magma were frequently mixed and B sugar had to be melted occasionally, while in other instances there was a lack of B sugar footing and it had to be replaced by C sugar magma for A strikes footing.

Besides, there was a shortage in commercial sugar centrifugals, the cause being the way the installation was made, and it was impossible to use more machines for A strikes and less for B strikes.

With the experience of Florida, we decided to try the system in Louisiana. The system was implemented at St. Mary Sugar Coop. This factory was almost ideally equipped and would take relatively minor investment to complete the equipment. An additional magma seeder, mingler, and magma pump were installed.

We had one high grade sugar Silver continuous centrifugal and with the addition of one high grade Western States continuous machine we completed the centrifugal equipment for B sugar.

The results of St. Mary for the 1975 grinding season were excellent. We not only produced a sugar of excellent quality as was expected, but the sugar recovery was greatly improved as well as the pan capacity.

In this particular instance, after a few adjustments at the beginning of the crop, we were able to use all the C sugar for B strikes footing and all the B sugar for A strikes footing. No sugar was melted at any time. Perhaps this fact contributed appreciably to the relatively low steam requirement of the boiling house.

For the 1975 crop, St. Mary Sugar Co-op processed 223,549 gross tons of cane and produced 41,344,584 lb of 98.58 average pol sugar.

Average material analyses were as follows (syrup = 83.77 purity):

	cu ft/ton cane	brix	pol	purity
A massecuite	3.61	93.27	77.09	82.65
B massecuite	1.65	94.69	66.70	70.44
C massecuite	1.07	98.12	55.51	56.57
A molasses				63.26
B molasses				49.02
Final molasses				30.88

Gal 80° brix final molasses/ton of cane = 5.76
Lb R.V. sugar/gross ton = 193.31
Lb R.V. sugar/net ton = 215.15
Lb R.V. sugar/std. ton = 177.16

Our routine work was to make a B strike out of C magma footing approximately 50% of pan volume and complete the strike with A molasses.

We were normally making 4 A strikes out of a B magma footing at a proportion 12 cu ft of finished A massecuite to 1 cu ft of 90° brix B magma.

We found this system to be very simple and easier to carry out than any other boiling system since it takes away all the complicated maneuvers of the so-called combination in the pan floor. Once the routine is established, all the operations are always the same. This means a lot for pan capacity, which very many times is affected by the ability of the sugar boiler. In this system with normal supervision the need for a very skilled sugar boiler is minimized.

In the final analysis, what this system means in comparison with other conventional methods is that molasses exhaustion is done in two stages, on B strikes and of course on C low grade strikes.

The syrup is used mostly to finish commercial sugar massecuites and very little to develop grain; molasses is used extensively in developing grain.

Since all the commercial sugar is made out of high purity B magma footing (91 to 94 purity) and syrup, the quality of the sugar is greatly improved. Very little washing is required in the centrifugals, and, consequently, molasses run off is greatly diminished.

Boiling a B strikes out of a partially developed grain, trying to make a good sugar with good molasses exhaustion, always has been the most difficult massecuite to boil. This is totally eliminated with this boiling system.

B massecuite is boiled out of a footing with numerous grain; it is very absorbent and very seldom gives trouble. Purity drop between B massecuite and B molasses increases resulting in a low purity B molasses that in turn gives us a low C massecuite with great possibility of good final molasses exhaustion. We proved this case with a lot better sugar recovery.

We feel that the additional investment required in most sugar factories is minimum in comparison with the benefits derived from this procedure, so we do not hesitate to recommend considering implementing this boiling system.

CAPACITY DETERMINATION OF CONTINUOUS CENTRIFUGALS BY PURITY METHOD

Peter Schubert
CF and I Engineers, Inc.
Denver, Colorado

ABSTRACT

Massecuite, a mixture of sugar crystals and mother liquor, is centrifuged to physically separate the mother liquor (molasses) from the crystals. The percentage of sugar crystals and mother liquor in a massecuite can be calculated from the known purities of the massecuite, the sugar, and the mother liquor. Molasses purity is higher than that of the mother liquor, since small sugar crystals passing the working screen of the centrifugal add to molasses purity. The influence of this purity difference on the calculation of capacity ranges from one to two percent; more accurate calculation of capacity is based on the rectangle method following the adjustment of sugar brix and mother liquor brix to that of the massecuite prior to calculating sugar and molasses purities. Use of water and/or steam in the centrifugals and sampling sequence introduce errors which require correction in the calculations.

CONTROL OF PARTICULATE EMISSIONS WITH A WET SCRUBBER

William D. Arlington
Florida Sugar Cane League
Clewiston, Florida

ABSTRACT

In order to protect air quality, it is necessary to control particulate emissions from stacks. Such emissions generated by steam boilers can be controlled by the use of an abatement device called a scrubber. The most effective type of scrubber has proven to be a wet scrubber, and the type of wet scrubber most generally used by the Florida Sugar Industry is the Joy Turbulaire type-D scrubber. The Joy scrubber is an impingement-type scrubber, which operates by passing flue gas through an air-water interface at a high velocity, causing particulate matter to be trapped in the liquid phase and flushed away. The process is complex and, in order to gain maximum efficiency from the unit, the following must be considered: a proper-sized scrubber must be selected according to boiler steam production rate and the volumetric flow rate of the existing gases; correct operating conditions must be maintained, i.e., the level of the scrubber liquid, sufficient scrubber water flow, and the correct pressure drop are direct functions of the success of the system; and the unit must receive regular maintenance, i.e., replacement of worn parts and cleaning of all functional areas. Off-season maintenance should provide for extensive overhaul to include the sump area, checking for corrosion, and welding of weakened areas. Effective emissions control also encompasses good boiler operation. This, in turn, reduces measurably the particulate load going to the scrubber. The correct combination of oil and bagasse can be utilized to achieve proper combustion. Uniform steam production will reduce heavy surges of particulates; the proper percentage of excess air will aid the combustion of the fuel. Source testing can also be an important step in reducing emissions. A comprehensive test should include the following parameters: stack-gas moisture; percent composition of gases; stack-gas velocity; temperature; and scrubber-water solids. These are often indicators of scrubber and boiler performance, and can determine what adjustments are necessary to improve efficiency. Present testing methodology, consistent with Florida state standards, is a modified version of that used by the United States Environmental Protection Agency. The procedure consists of sampling the flue gases through a heated probe and filter, and bypassing them through ice-cooled impingers. The volume of the gas is measured by using a dry gas meter; gas velocity in the stack is measured simultaneously. Emission rates are determined by dividing the weight of the trapped particulates by the sample gas volume, and then multiplying this result by the volumetric flow rate of the stack-exit gases. In conclusion, the wet scrubber provides a high degree of particulate abatement when operated and maintained in the above described manner.

BAGASSE BOILER STACK CLEANING

A. V. Barron, Jr.
Barron/A.S.E., Inc.
Leeds, Alabama

ABSTRACT

Equipment, capabilities and performance, and the code compliance standards for dust collector systems for sugar-mill boilers are evaluated. The energy requirements of the various systems i.e., principally mechanical dust and wet scrubbing, their common field problems and solutions providing proper operation are compared. Simple modifications to existing equipment to improve performance are described.

SOME ASPECTS OF INDUSTRIAL WATER POLLUTION

Robert C. Adams
U.S. Sugar Corp.
Clewiston, Florida

ABSTRACT

Discharge of industrial wastes to receiving water is acquiring increased attention, not only because regulatory agencies are requiring stricter compliance to satisfy standards of water quality, but also because of economic considerations in disposal of wastes. Specific types of wastes associated with the production of sugar, including factory effluents and agricultural runoff. are discussed. Certain physical, chemical and biological characteristics of these wastes are considered, along with the effects wastes have on receiving water e.g., dissolved oxygen levels, sedimentation, BOD, ecosystem imbalance, et al. Present EPA and state water quality standards are presented, and methods for analyzing selected pollution indices are examined.

HOW PRACTICAL IS THE CONVERSION OF SUGARCANE PRODUCTS INTO FUELS AND CHEMICAL FEEDSTOCKS?

Edward S. Lipinsky
Battelle's Columbus Laboratories
Columbus, Ohio 43201

ABSTRACT

The United States is consuming about 75 x 10^{15} BTU's per year of energy and is likely to consume 150 x 10^{15} BTU's by the year 2000. To meet this enormous energy demand, the United States is seeking to develop previously under-used resources, including solar energy. Battelle has been conducting a research program, one goal of which is to evaluate the use of sugarcane and sugarcane fiber (bagasses, tops and leaves) as a source of fuels. Conversions of cane juice to ethanol, fiber to methane, methanol and various liquid fuels are under active investigation. Comparisons of the use of these fuels and chemical feedstocks with use of fiber for generation of steam and electricity is underway. Initial findings with regard to both technical and economic promise will be presented for discussion.

INTRODUCTION

The quadrupling of the selling price of crude petroleum by the Organization of Petroleum Exporting Countries (OPEC) in 1973 will have a continuing impact on individual and corporate life in the U.S. for decades to come. The OPEC countries generally are less developed countries and their view of the situation--that their petroleum constitutes the patrimony with which to achieve the aspiration of their citizens--probably will restrain them from any major price declines toward the good old days. A more reliable forecast would be that the rising expectations of the citizens of the OPEC countries will lead to pressures to increase petroleum prices further. The U.S. is not blessed with cheap petroleum and its coal reserve, although vast, poses serious safety and environmental problems. Therefore, the U.S. needs to develop renewable energy resources. Agriculture is one such resource but which crops are the best candidates?

SUGARCANE AS A CANDIDATE ENERGY RESOURCE

The major merits of sugarcane as a candidate energy resource are as follows:

1) Sugarcane is renowned for its agricultural productivity (4).
2) Sugarcane juice can be fermented to ethanol directly, in contrast with cellulosic starting materials.
3) Sugarcane has low sulfur and low ash contents and is not radioactive.
4) Sugarcane is renewable and does not disturb the ecological systems of the earth's biosphere.
5) Considerable fiber is delivered to the mill along with the salable sugar products, in contrast with corn which is shelled in the field and with crops grown exclusively for energy production.

In contrast with these sugarcane merits, coal, nuclear energy, and oil shale have serious drawbacks, especially in safety and environmental impacts.

To balance the picture, sugarcane does have the following drawbacks:

1) Sugarcane products are valuable in food and feed applications and their conversion to energy can be considered an underutilization of their potential value.
2) Land of sufficient quality to grow sugarcane on a highly productive basis could be used to grow other foods and feed crops on a highly productive basis.
3) Unlike corn and some other field crops, land area in the U.S. that is suitable for high-productivity sugarcane production is limited.
4) Relatively few farmers in the U.S. are conversant with the highly specialized agricultural technology required to grow sugarcane successfully.
5) Sugarcane is costly to grow in terms of energy requirements, capital investment, labor, and other inputs.

These drawbacks are serious and in Battelle's opinion will tend to limit the contribution of sugarcane to the solution of the energy problem to less than 2 quads of energy in the 1985-2000 timeframe. Considering that U.S. energy needs will exceed 100 quads (3, 5), such a modest goal might seem unimportant. Of course, this energy problem will not be solved by one or two major new resources but rather by small contributions from many new resources.

CONVERSION POSSIBILITIES

The major conversion possibilities under study at Battelle are the following:

1) Direct production of electricity and steam by combustion.
2) Production of substitute natural gas (SNG) thermochemically or by fermentation.
3) Production of ethanol by fermentation.
4) Thermochemical production of methanol via synthesis gas.
5) Thermochemical production to ammonia via synthesis gas.

The interrelations among these opportunities are shown schematically in Fig. 1. For reasons of brevity, only ethanol, methanol, and ammonia will be discussed in this paper. Direct production of electricity and SNG will be discussed by Battelle in subsequent papers.

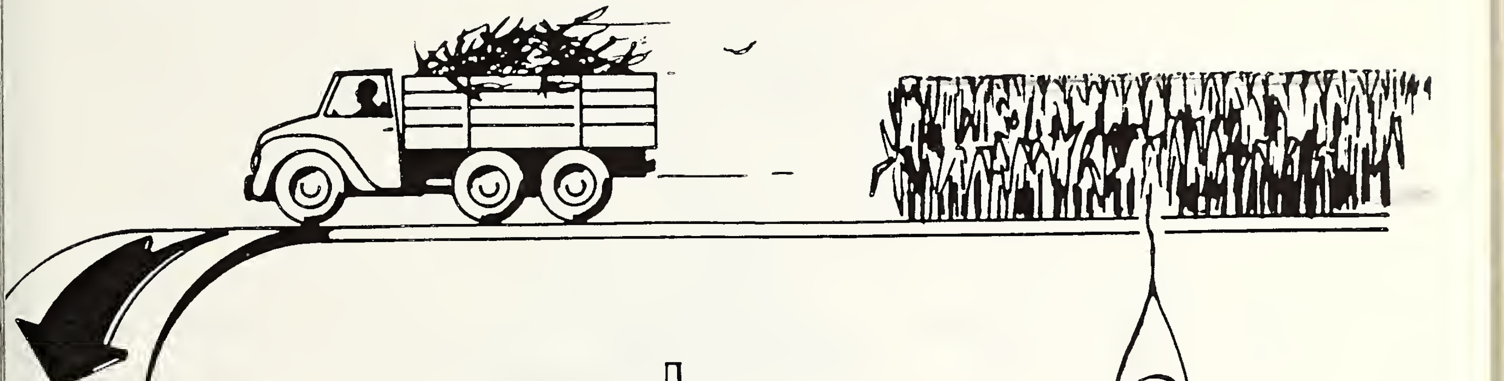

Figure 1. Conversion of Sugarcane Products into Fuel and Chemical Feedstocks

ETHANOL FROM SUGARCANE

The manufacture of rum from molasses and the impromptu production of white lightning from sugarcane squeezings is so well known that it is unnecessary to debate the technical feasibility of manufacturing ethanol from sugarcane by fermentation technology. The major problem arises when the goal is to manufacture a significant quantity of ethanol from sugarcane products cheaply enough to have an impact on the energy problem.

The general concept is to make use of the fibrous sugarcane by-products to manufacture the steam for crushing and milling the agricultural inputs, with enough steam left over to conduct the ethanol distillation (Fig. 2). Battelle has made preliminary, rough estimates of the manufacturing cost for ethanol on a 70-million-gallon-per-year scale (Table 1). This scale is approximately 25% of current U.S. ethanol production for industrial uses and would be equivalent to approximately 50 million gallons of gasoline per year. This is the scale that a 40,000-60,000 acre plantation or cooperative might produce. This approach is practical in contrast to the grand schemes that involve cultivation of sugarcane on 10,000 square miles of land in the arid west.

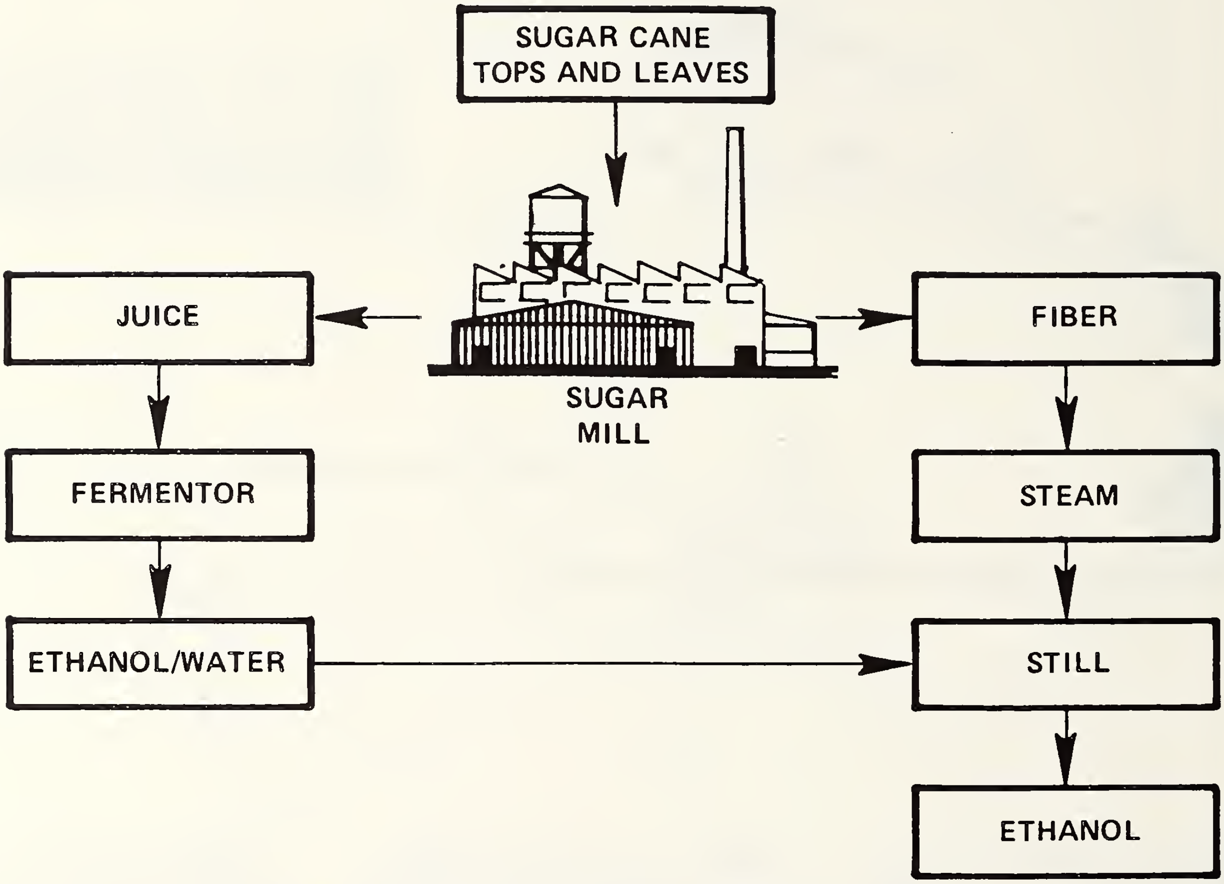

Figure 2. Manufacture of Ethanol from Sugarcane Products.

Using data supplied by many sources, Battelle estimates that cane juice might be obtained for approximately $0.06 per pound of fermentable solids and fiber might be obtained for approximately $1.00 per million Btu's. This process manufactures significant quantities of stillage (distiller's dried solubles). When an appropriate penalty is applied to the stillage product because of its relatively high ash and low protein content, then the net manufacturing cost of ethanol appears to be approximately $1.10 per gallon (Table 1).

How much should ethanol cost to be competitive with gasoline? As shown in Table 2, the gasoline for which one pays $0.57 per gallon has a very low cost at the refinery--somewhat less than $0.33 per gallon. Taking this as a genuine starting point, since ethanol has only two-thirds the energy of gasoline, it should cost $0.22 per gallon to compete on a purely economic basis. One can cite anti-knock and pollution abatement advantages for ethanol. However, this low energy product costs more per Btu to ship. Actually, the situation is even worse than stated above. The regional selling price for gasoline consists of $0.22 per gallon raw material costs and $0.10 per gallon operating costs, profit, etc. In fact, the $1.09 ethanol cost should be compared with some figure between two thirds of $0.22 and $0.33. Therefore, fuel ethanol has a value between $0.15 and $0.22 per gallon.

Table 1. Estimated manufacturing costs of ethanol from sugarcane juice.

		(In millions of dollars)	
Capital Investment			
Battery limits plant(a)		49.0	
Utilities, offsites, etc.		24.0	
Interest during construction		9.0	
Working capital and startup expenses		24.0	
Total		105.0	
Annual capital charges, 20 yr, 9%			11.6
Operating and Maintenance			
Nutrients and denaturants		2.0	
Utilities: steam at $3 per 1,000 lb		16.8	
other		0.6	
Labor and supervision		1.6	
Maintenance		1.8	
Overheads, supplies, indirects		2.4	
Taxes and insurance		1.6	
Total			83.0
Raw Materials Cost			
Cane juice at $0.06 per lb		56.5	56.5
Credits			(20.4)
Net manufacturing cost			74.2
Net Manufacturing Cost (in dollars per gallon)	1.08		

(a) Excludes steam plant, includes fermentation at $35 million and distillation at $11 million.

Table 2. Gasoline prices at various points in the channels of distribution, mid April, 1976.

Level of Distribution	Price, Cents Per Gallon
Pump	57.0
Retail ex Taxes	45.9
Dealer	36.8
Regional	31.8-36.5
Crude Oil Cost Component(a)	22

Source: National Petroleum News, June 1976, p. 12.

(a) Battelle estimate.

The prospects are much brighter for industrial ethanol than for fuel ethanol. The present selling price of denatured ethanol is $1.15 per gallon.

One must be cautious in comparing a projected manufacturing cost of $1.08 in new facilities with a selling price of $1.15 made in well-amortized facilities. A manufacturing cost of $1.08 is probably equivalent to a selling price of $1.50 per gallon. The 4.2 lb of ethylene contained in a gallon of ethanol now costs about $0.50. An ethylene price of $0.21 would lead to an ethylene cost component for petrochemical ethanol of $0.90 per gallon. If the $0.65 margin that now applies were used as a markup, a selling price of $1.55 per gallon would result. Because one can expect $0.21 per pound ethylene from $21 per barrel petroleum, the crossover point between petrochemical ethanol and fermentation ethanol would be approximately $21 per barrel for petroleum. If petrochemical companies preferred to sell ethanol for double the ethylene cost, the crossover point would be about $17 per barrel. However, public opinion and federal policy would hold the margin close to $0.50 per gallon, in our opinion. This preliminary analysis indicates that the crossover to fermentation would become likely as petroleum approaches $20 per barrel and as ethylene approaches $0.20 per pound. This price increase would come to pass and is well worth providing for.

THERMOCHEMICAL PROCESSES

A major fault in making ethanol from sugarcane is that the juice that is employed for fermentation is the same juice that is used to make crystalline sucrose and feed molasses. Sugar fiber is used in that concept only to manufacture steam. It is logical to seek ways to make the fiber into fuels or chemical feedstocks and to maintain the opportunity to sell crystalline sucrose and feed molasses. Accordingly, Battelle is investigating the conversion of sugarcane fiber products into methanol and ammonia by thermochemical processes.

Since several processes for converting municipal solid waste (MSW) into synthesis gas (carbon monoxide and hydrogen) have been under development, Battelle examined MSW thermochemical processes first. Sugarcane fiber's major advantages are much less ash and much more consistent composition than MSW. MSW's big advantage is having about half the moisture content of sugarcane fiber.

The front-running process for making carbon monoxide and hydrogen from MSW is Union Carbide's Purox® process (7). The Purox process has reached the demonstration plant stage. Other processes may appear cheaper but have not survived pilot plant and demonstration runs. Sugarcane fiber could be converted into carbon monoxide and hydrogen at a cost of approximately $2.40-$3.50 per million Btu's (Table 3). The major cost element is the energy-intensive and capital-intensive facility. Pure oxygen is an essential ingredient of the Purox process and its manufacture from air requires a major capital investment and much electricity for operation.

Table 3. Estimated manufacturing costs of synthesis gas via the Purox process.

	(In millions of dollars)	
Capital Investment		
Battery limits plant	36.0	
Other fixed investments[(a)]	9.5	
Interest during construction and startup	8.7	
Total	54.2	
Annualized Capital Charge, 20 yr, 9%		6.0
Operating and Maintenance		
Power at 0.02/kwh	1.9	
Miscellaneous at $0.60/dry ton	0.3	
Labor and supervision	0.8	
Maintenance	1.2	
Supervision, payroll burden, supplies, indirect costs	1.6	
Taxes and insurance	1.1	
Total		6.9
Raw Material Cost		
Sugarcane fiber at $/MM Btu	7.8	7.8
Net Manufacturing Cost		20.7
Net Manufacturing Cost (in dollars/million Btu) 3.00		

(a) Includes land, site preparation, utilities, and services.

Methanol. Starting from synthesis gas at about $3.00 per million Btu's, Battelle estimates that the manufacturing cost of methanol would be about $0.66 per gallon (Table 4). Again, this manufacturing cost should be considered rough, approximate, and preliminary. The methanol manufacturing cost is based on ICI technology that is a commercial reality.

Table 4. Cost of methanol from Purox output.

	$ Million
Cost of Purox Output	20.7[(a)]
Cost of Methanol Synthesis	8
	28.7
Cost per MM Btu Methanol	12
Cost per gallon	0.66

Source: Battelle estimate.

(a) Assumes sufficient waste heat available to reduce fiber moisture from about 49% to about 25%.

These methanol manufacturing costs are higher than those based on coal about which you may have read in chemical engineering journals. When methanol manufactured from coal is studied, huge plants that are 25 times the size of the facilities that sugar processors would use are postulated. There are significant economies of scale which our small 475 ton per day plants cannot hope to match. Big plants have about half the unit costs of small plants.

How good a fuel is methanol? Methanol has only half the energy content of gasoline. Consequently, the manufacturing cost of methanol would have to be less than $0.16 per gallon just to compete with the gasoline made from petroleum that averages $9 per barrel. Using the type of analysis presented for ethanol, the motor fuel crossover point would be $49 per barrel on a passthrough basis. If the producer were permitted to raise his margin proportionately with raw material cost increases, the crossover point would be $36 per barrel. Thus, methanol from sugarcane appears to be an uneconomical fuel when fiber is valued at $1 per million Btu's, oxygen is made on a small scale, and a small methanol facility is built.

As with ethanol, methanol has many chemical uses. The market for chemical methanol for use as a solvent and as starting materials for an entire family of industrial chemicals is 3.5 million tons per year (1), which is about 3 times the volume of the ethanol market. The selling price of chemical methanol is approximately $0.40 per gallon.

Battelle estimates that a gallon of methanol contains approximately $0.15 of natural gas. The manufacturing cost is approximately $0.30 per gallon on a basis similar to that used in the fiber-to-methanol calculations. Therefore, the crossover point with $0.66 per gallon methanol would be reached at about $3.60 per million Btu's. If methanol producers were permitted to obtain a proportional upcharge for their higher raw material costs, crossover could occur at approximately $2.20 per million Btu's. These crossover prices are much closer to realization than would be the ethanol crossovers because no new OPEC actions are required.

Fertilizer Ammonia. Although ammonia has a high energy content, it seems most appropriate to evaluate ammonia from the outset of its major application--fertilizer. Ammonia is made from the thermochemical reaction of nitrogen and hydrogen with special catalysts. The oxygen plant used in the Purox process manufactures both oxygen and nitrogen and uses the oxygen to make synthesis gas. Some of the nitrogen could be used as raw material and the low temperature could help in product recovery.

The United States manufactures approximately 17.5 million tons (1) of ammonia per year, which makes this product a much bigger market than ethanol and methanol put together. Ammonia manufacture consumes approximately 3% of U.S. natural gas production and represents a major focal point for future fuels savings. The market prices for ammonia are quite artificial because the natural gas used in its production is still valued at levels that are not equilibrated with the 1973 energy price increases. The raw material costs are likely to increase by $50-$100 per ton of ammonia product within the next 10 years just to catch up with the 1973 energy price increase.

When ammonia is made from natural gas from the Gulf coast or brought in from Trinidad or Venezuela, there are transportation costs and losses of ammonia that can amount to as much as 5-10% of the selling price in value. Therefore, local production of ammonia close to the point of end use can have an economic advantage that can partly offset the economies of scale advantage that the large Gulf coast and foreign facilities have.

Battelle's rough, approximate, preliminary calculation of ammonia manufacturing cost from sugar fiber is about $200 per ton (Table 5). If the present manufacturing cost of ammonia in facilities still needing amortization and with $1.50 per million Btu gas is $125 per ton, the passthrough crossover point would be about $3.75 per million Btu's. If a proportional margin were maintained, crossover would occur at about $2.70 per million Btu's. These crossover points are well within the realm of possibility.

Table 5. Estimated manufacturing costs of ammonia. Scale: 568 short tons per day; 330 days per year.

	(In millions of dollars)	
Capital Investment		
Battery limits plant (BLP)	30.0	
Other fixed investments[a]	17.8	
Interest during construction and start up costs	13	
Total	60.8	
Annualized capital charge, 20 yr, 9%		6.7
Operating and Maintenance		
Labor and supervision	1.47	
Overheads, supplies, indirects	3.73	
Taxes and insurance	1.07	
Utilities: Steam, 1,353 M lb/D, 330 D/yr @ $3/M lb	1.34	
Electricity	4.17	
Offgas credit at $1/MM Btu	(3.12)	
Total		8.7
Raw materials		
Purox gas cost	18.50	
Nitrogen	2.00	20.5
Net Manufacturing Cost		35.9
Net Manufacturing Cost (in dollars per ton)	197	

(a) Includes offsites and services and 5 months' product storage.

CONCLUSIONS

As of June, 1976, it is not possible to give the definitive answer to the question "How practical is the conversion of sugarcane products to fuels and chemical feedstocks?" The practicality is not within control of the United States. Barring vindictive and economically irrational acts by the OPEC countries, manufacture of fuels for direct use in our automobiles does not appear likely in the next decade or two. However, manufacture and sale of such materials as ethanol, methanol, and ammonia for non-fuel usage is relatively close to the crossover point, compared with fuel uses. The manufacture of 20 million tons of these chemicals from natural gas and/or petroleum sources uses U.S. fuel resources at the rate of several quads per year. Therefore, use of sugarcane to replace natural gas and petroleum for making ammonia, methanol, and ethanol could contribute significantly to the amelioration of the U.S. energy problem.

What can sugar technologists do to help reduce the dependence of the U.S. on petroleum and natural gas? The calculations presented in this paper use the sugar technology developed over the years to optimize crystalline sucrose production. Our investigations confirm what sugar specialists have known all along--that new sugarcane varieties and agronomic practices could reoptimize this crop to provide chemical feedstocks more cheaply. Changes in sugarcane processing at the mill are needed to enhance the suitability of the fiber for thermochemical conversion to chemicals. Some of the major concepts for this reoptimization will be a subject of a forthcoming Battelle report and tutorial conference.

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ENERGY AND OUR OPTIONS

A. V. Barron, Jr.
Barron/A. S. E., Inc.
Leeds, Alabama

ABSTRACT

National energy demands and their effects on industry and business are discussed. Conceptual ideas are offered to plan for reducing the impact of a projected energy shortage on national and international business economics.

PAPERS PRESENTED AT 1976 MEETING OF FLORIDA DIVISION

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FOUR PROMISING RESEARCH AREAS IN SUGARCANE BREEDING

P. M. Lyrene[1]
Agricultural Research and Education Center
Florida Agricultural Experiment Station
Belle Glade, Florida

ABSTRACT

Most new sugarcane varieties are produced by selection of superior F_1 seedlings from crosses involving commercial and promising test clones. Research in several areas of sugarcane breeding promises to improve and supplement present variety-development procedures. Methods for evaluating the breeding value of potential parents will allow selection of parental combinations giving superior F_1 populations. Crosses with previously unused Saccharum officinarum clones will increase diversity and reduce inbreeding in seedling populations from which varieties are selected. Tissue-culture induced mutations may correct certain types of defects in clones that are otherwise superior. Development of varieties that can fully exploit new cultural practices such as narrower row spacings and chemical sucrose enhancers may result in significant increases in sugar yields.

INTRODUCTION

Most new sugarcane varieties are selected F_1 seedlings obtained from crosses involving commercial varieties and promising experimental clones. The rather empirical method now used in sugarcane breeding has been very successful in the past, and will continue in the future to be the primary method of variety development. The science of sugarcane breeding is progressing, however, and the purpose of this paper is to describe four areas of breeding research which may, in the future, expedite sugarcane variety development. Obviously no brief discussion can cover all promising areas of sugarcane research, nor can it more than exemplify research progress in the areas discussed.

PARENTAL EVALUATION

The number of different crosses that can be made with n sugarcane clones is given by the formula $n(n-1)/2$. For 100 breeding clones, the number is 4950. Sugarcane breeders commonly have hundreds of clones that could be used as parents, and the number of possible parent combinations far exceeds what can be tested. Crosses vary widely in quality, some producing many excellent seedlings with cultivar potential and others producing mostly weak seedlings, few of which would make good cultivars. Obviously, breeders would like to know in advance which parental combinations would produce good seedlings and which would produce poor.

Prediction of cross potential is greatly simplified if it is assumed that some sugarcane clones are good parents and others are poor parents, regardless of what clones they are mated with. This assumption is not completely valid, but is probably accurate enough to be useful. A problem which immediately arises is how best to determine whether particular clones are good or poor parents. A starting point is the rule that like begets like, that is, good varieties make good parents. Sugarcane breeders make wide use of this rule but realize that some excellent varieties are poor parents and some poor varieties are good parents.

A second method by which the breeding potential of sugarcane clones can be evaluated is evaluation of S_1 seedlings. If 100 potential breeding clones could be self pollinated and the 100 S_1 populations compared in a replicated test, the breeder would have a valuable measure of the relative abilities of various clones to transmit good varietal characteristics to their offspring. Hopefully, then, the best crosses would be those between clones which produce good S_1 populations. These promising crosses would be made first, and less promising crosses would be made only if time allowed.

A third method for evaluating parents is the topcross, in which a series of test parents are crossed individually with one standard parent, which may be a commercial variety or an inbred line. F_1 populations from the crosses are compared, and test parents giving the best populations are assumed to have the highest potential as parents.

An effective method for determining breeding value in sugarcane clones would allow intelligent use of a larger number of breeding clones. Experimental clones in early stages of variety development could be evaluated as parents, and those proving to be good parents could be used in breeding years earlier than would otherwise be possible. In view of its great potential, much more data should be collected on the effectiveness of parental evaluation.

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[1] This work was done at the USDA Sugarcane Field Station, Canal Point, Fla.

NEW NOBILIZATIONS

Prior to 1900 the so-called noble cane varieties (Saccharum officinarum L.) accounted for most of the world's sugarcane production. Today, almost all sugarcane production is from high-chromosome number hybrids based on S. officinarum and S. spontaneum L., with possible minor inputs from a few other Saccharum species. Because most of the chromosomes of modern commercial sugarcane cultivars trace back to S. officinarum, S. officinarum genes are clearly of primary importance in sugarcane breeding. Yet, of the hundreds of S. officinarum varieties in the world collections, only a handful were used in the development of commercial sugarcanes, and there is little to suggest that the ones used were necessarily the best that are available. Furthermore, with cross-pollinated crops like sugarcane, in which maximum vigor depends upon maximum heterozygosity, seedlings show decreased vigor if they trace back to too small a sample of ancestors.

Within the past decade, several sugarcane breeders have been making crosses to bring genes into commercial sugarcanes from previously unused noble varieties. These crosses promise to increase variability and vigor in the seedling populations from which commercial varieties are selected.

MUTATIONS IN TISSUE CULTURE

Breeders of seed-propagated crops in which varieties are either relatively homozygous pure lines (the small grains, soybeans, etc.) or hybrids of inbred lines (maize, sorghum, etc.) have, in the backcross procedure, a systematic, reliable method for altering one feature of a variety while maintaining other features almost unchanged. In these crops, if a promising variety has one serious defect which is controlled by one or two genes, that defect can, in essence, be removed from the variety by the backcross method if related varieties lacking the defect are available. With sugarcane and other heterozygous, vegetatively propagated crops in which particular genotypes cannot be exactly reproduced by seed, the backcross method does not produce the desired results. Because of heterozygosity, aneuploidy, and the fact that only a few generations of selection have occurred since the original synthesis of commercial sugarcane hybrids, few F_1 seedlings, even from good crosses, are of commercial quality, and the expense of identifying a good variety is substantial. Thus, a technique by which an excellent but defective variety could be made useful by removal of the defect could be a helpful adjunct to conventional sugarcane breeding procedures. Plant tissue culture may be such a technique.

Sugarcane tissue culture is a procedure in which fragments of leaves or flowers are placed on a specially-prepared nutrient medium under conditions which induce formation of small sugarcane plants from the fragments. Tissue culture is vegetative reproduction, and in theory, one would not expect the newly formed plants to deviate from the parent type. In practice, however, deviations occur at high frequency, not only in sugarcane, but also in dozens of other economically important plants that have been grown in tissue cultures. Most of these deviations are deleterious, and result in dwarf, albino, or unthrifty plants. Other changes, however, are of the type sought, in which one varietal trait is altered while the other principal traits remain the same. Although the mechanisms by which these changes arise at such high frequency are poorly understood, the changes themselves have been reported so frequently and with so many different plant species that they hardly can be denied.

In sugarcane varieties CP 57-603 and H 57-1627, variants have been reported which have acquired resistance to eyespot disease (Bipolaris sacchari) (2); and variants of susceptible variety Pindar have been reported resistant to Fiji disease (3).

It is too early to properly assess the potential of tissue culture mutagenesis in sugarcane breeding, but the technique presently seems very promising.

BREEDING FOR NEW CULTURAL PRACTICES

Advances in agricultural technology are sometimes delayed because agricultural research is fragmented into separate disciplines such as plant breeding, agronomy, soil science, and agricultural engineering. Although this fragmentation has several advantages and probably is unavoidable in an age of proliferating information and increasingly sophisticated research tools, it also has a serious disadvantage in that it encourages discipline-oriented research and discourages problem-oriented approaches.

Some promising research areas in sugarcane breeding have both varietal and cultural aspects. For example, preliminary evidence from several sugarcane areas suggests that 5-foot (1.5m) row spacings may severely reduce yields compared to narrower spacings (1, 4). Changing an entire industry to narrower row spacings, however, or even conducting field experiments large enough to conclusively measure the effect of various spacings, requires new machines to plant, cultivate, and harvest the cane as well as new varieties that will fully exploit the narrow-row environment. A study by Bull (1) showed that sugarcane varieties do best when grown under the particular row spacings for which they were developed.

Sucrose enhancement is a research area in which sugarcane breeders and agronomists may work together with great profit. Sugarcane varieties differ in their responses to chemical sucrose enhancers, and in the future, sucrose yields may be greatly increased by coordinated development of more-effective sucrose enhancers and of sugarcane varieties especially designed to respond favorably to them.

Vegetative propagation has had an enormous impact on the development of sugarcane breeding as a science. Because of vegetative propagation there has been no need to devise genetic systems that would allow varietal propagation through seed. Consequently, sugarcane genetics has received inadequate attention in the past. In the future, however, the science of sugarcane breeding is likely to develop more rapidly, and that development will bring better sugarcane varieties and higher sugar production.

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SOIL AS A FACTOR IN FLORIDA SUGARCANE YIELDS

G. J. Gascho
Agricultural Research and Education Center
Florida Agricultural Experiment Station
Belle Glade, Florida

ABSTRACT

Florida sugarcane and sugar yields in fields close to Lake Okeechobee are outstanding in comparison to yields distant from the lake. It is generally believed that the yield differences are due to the modifying temperature of the lake as evidenced by the terms warm land close to the lake and cold land distant from the lake. An experiment was conducted to determine the effects of soil differences on yields when climate was standardized. Sugarcane was grown out of doors in barrels at the A.R.E.C., Belle Glade. Six soils with 4 replications were used. Five of the soils were of sawgrass origin and are now classified as Terra Ceia, Pahokee, or Okeelanta mucks; the sixth was a custard apple soil presently classified as Torry muck. Fertilizers were applied according to soil test but all barrels were watered equally. Under the same climatic conditions, yields of sugar per barrel averaged 79% higher for cane grown in the custard apple soil in comparison to cane grown in the soils of sawgrass origin. The yield difference was related to soil properties and emphasizes the importance of soil in Florida sugarcane production.

FIELD MONITORING TO DETERMINE THRESHOLD OF ECONOMIC LOSS DUE TO THE SUGARCANE BORER, DIATRAEA SACCHARALIS

T. E. Summers[1], J. R. Orsenigo[2], and G. Kidder[3]

ABSTRACT

Based on a raw sugar yield of 8,000 lb/A, raw sugar price ca $0.15/lb, and current chemical treatment costs, an economic return from control measures may be expected when an early season field borer infestation level exceeds 2% of the stalks when survey determinations are averaged for the entire field. The destruction of a larval population with the potential of producing 800-1000 mature borer larvae per acre should provide an economic return over the cost of one control treatment. A method and the factors involved in arriving at the economic threshold are discussed.

The absolute economic loss due to the feeding of specific populations of sugarcane borer larvae will vary according to such factors as stage of plant growth when first damaged, tolerance of the variety, weather during hatching, populations of parasites and predators, and entomophagous diseases. Thus Hensley (2) stated in Louisiana that a total of 10% bored joints resulted in a reduction of 1.5 tons of cane per acre. Schaff (3) reported that in Jamaica bored internodes produced 45% less sugar than undamaged internodes.

The actual losses that result from sugarcane borer damage occur in several ways: because the number of millable stalks is reduced, because of a loss in gross tonnage, because an increased amount of stalk material contains no sucrose, or because invasion of stalks by secondary organisms such as fungi reduces juice quantity and quality (and possibly the production of nonsucrose sugars). However in Florida, each 1% of bored joints is considered to represent an overall loss of 1% sugar when all these factors are considered. Therefore, in arriving at a workable and valid scheme for determining a threshold of borer infestation that could be used in determining the need for chemical control, we based our calculations on the damage potential (percentage bored joints) of a single healthy sugarcane borer larvae. We were also guided by the factors affecting the threshold at which chemical control becomes economical or profitable such as:

1. Market price of sugar.
2. Estimated yield per acre.
3. Number of potential millable stalks per unit area.
4. Number of potential internodes per stalk and per unit area.
5. Variety susceptibility or resistance to borer damage (All Florida commercial varieties at this time are susceptible).
6. Cost of insecticides and cost of application.
7. Number of borer larvae present and number of those present that are parasitized.
8. Time of infestation. For example, a 2% infestation in September or October probably would not be considered important, but an infestation of the same size in May or June would have a potential for increasing populations.

In step A, arbitrary average values were assigned each of the 8 factors. These values have been confirmed as both possible and reasonable on the basis of experience and data collected over the past years. Of course, in an actual situation, values should be varied to fit known information, (such as soil type, water control, plant or stubble cane, distance from Lake Okeechobee, etc., with which each grower is familiar).

	Factor	Value
1.	Price of raw sugar	$0.15/lb
2.	Potential yield, cane	40 T/A
3.	Potential yield, sugar	8,000 lb/A
4.	Potential millable stalks	40,000/A
5.	Potential internodes/stalk	18/stalk
6.	Potential internode (total)	720,000/A
7.	Variety is susceptible, and 1 borer damages average of 3 internodes	
8.	Cost of material and application	
	Single application	$4.00
	3 applications	$12.00
9.	Month	June

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[1] USDA, ARS, Canal Point, FL 33438.

[2] Agricultural Research, Florida Sugar Cane League, Inc., Clewiston, FL 33440.

[3] University of Florida, IFAS, Cooperative Extension Service, Belle Glade, FL 33430.

Then in step B, the threshold was calculated as follows:

1.	Return from 8,000 lb sugar @ $0.15	$1,200.00
2.	40,000 stalks with 18 internodes each	720,000
3.	720,000 internodes worth	$1,200.00
4.	One internode worth	$0.00167
5.	One healthy borer can damage 3 internodes; therefore, each borer potentially destroys	$0.005
6.	Cost of 1 chemical application	$4.00

So 2,200 internodes must be saved or 800 borer destroyed to defray the cost of 1 application of chemical. Also 7,200 internodes (a minimum of 2,400 borers destroyed) would have to be saved to defray the cost of 3 applications. In addition one acre of sugarcane equals 8,712 linear feet of row.

Thus the threshold for one application is reached if the damage done by 800 borers represents the cost of one chemical application, that is, when the infestation exceeds an average of 1 borer/11 linear feet of row, approximately a 2% infestation based on a percentage of infested stalks. If a three-application program is anticipated, an average of 1 borer/3.6 feet of row, that is, an approximately 6% infestation, would be required throughout the application period (1 borer/11 feet of row, three times).

However, the decision to treat at 2%, 6%, or any other level of infestation should be based in part on the percentage infestation during the first month of the season (May) since this and the number of parasites and predators present will determine the degree of damage that could be done by succeeding generations of the borer. The time needed for a complete life cycle of the borer is 28-45 days depending upon the temperature. In Florida, between June and September, it averages 30 days; however there is much overlapping of generations, and it is rare that more than three applications are required.

By our method, field surveys must be made to determine levels of borer infestation, and we have ourselves used several such systems. Our practice has been to sample five 43.5 feet row portions/40A block. These five samples are not rigidly systemized, but are made down and across each block.

Mr. Gene Dodgen (1) of A. Duda and Sons reported another method during the February 24 Sugarcane Grower's Seminar: Beginning June 1 surveys for sugarcane borer. Samples 50 ft of row at 4 places diagonally across a block. Sprays if 2% of stalks inspected have live borers.

Plainly, cane growers should be aware of the need to monitor fields from June 1 until the crop is harvested. They should also remember that fields sprayed with insecticides for control of aphids, mites, the less corn stalk borer, Elasmopalpus lignosellus (Zeeles), or other insects would be watched carefully since natural borer predator/parasite levels are depressed by spraying for the other pests.

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MID-GROWING SEASON BURROWING ACITIVITY AND RELATED DAMAGE OF THE FLORIDA WATER RAT (NEOFIBER ALLENI) IN A SUGARCANE FIELD

David E. Steffen and Patrick F. Scanlon
Department of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

INTRODUCTION

In sugarcane, the Florida water rat, Neofiber alleni, is a fossorial rodent living in distinct colonies. Samol (2, 3) indicated that this species rarely moves far from its burrow systems. The primarily subterranean existence of Neofiber differs from that of other rat species (mostly Rattus rattus and Sigmodon hispidus) inhabiting sugarcane. These other species may use Neofiber burrows for shelter or nesting, but trapping results (4) indicate that they spend considerable time away from burrows. This difference in habits between Neofiber and other rat species in sugarcane probably limits the effectiveness of standard control measures (e.g. baiting of field edges) against Neofiber. Knowledge of Neofiber behavior and ecology will enhance the ability to develop appropriate control techniques.

There are at least three types of damage which may be associated with Neofiber. Gnawing and consumption of the cane stalk (and possibly root systems) may result in either the death of the stalk or deterioration of the juice quantity and quality. Burrowing activity undermines cane stools which may cause reduced production or permanent damage to the stool. Burrow systems may aid in the start and spread of muck fires.

A study was undertaken in January 1976 to determine the distribution of Neofiber and to quantify the damage and burrowing patterns associated with its presence. The intent of this paper is to present data from this study on Neofiber burrowing activity and damage to sugarcane during the middle of the growing season.

METHODS

The west half of field 45-H-25 (18.8 acres) in the Western Division of the U. S. Sugar Corporation was selected for use in an intensive study of the burrowing and damage related to Neofiber. This field was selected because it contained a substantial number of separate Neofiber burrow systems (colonies). It also contained substantial areas without Neofiber burrowing activity from which to select control samples for use in damage assessment. The field had variety Cl 54-378; the third stubble was cut on 30 December 1975.

In March 1975, all burrow openings in colonies that showed active digging were marked with numbered stakes and mapped. In June, six of these colonies that still showed signs of burrowing activity were selected for further study. Old and new burrows in these six colonies were mapped each month from June through September.

In July, based on the June mapping, a random sample of 40 burrow sites was selected for damage assessment locations. The sample consisted of 15 sites selected from new burrows and 25 sites from old burrows. A new burrow was considered to be one that appeared since the March mapping, and an old burrow as one present in March. A sample point consisted of 8 feet of cane row, 4 feet on each side of the mid-point of the sample burrow.

The control sample consisted of 40 randomly selected sites (each 8 feet in length) along three established transects (cane rows) in the portion of the field that did not contain Neofiber burrows. These transects provided 1100 feet of cane row from which to select the control samples. Initially, all control samples were at least 100 feet from any group of burrows, either active or inactive.

The total number of stalks and the number of stalks damaged by gnawing were counted within each sample point. In addition, at burrow sample points, it was noted whether the central burrow directly undermined a cane stool.

The same procedure was followed in August. Sampling was based on maps made in August prior to damage assessment. Fifteen sample points were selected randomly from old burrows (burrows present in July or earlier) and 15 were selected randomly from new burrows. Forty control sample points were randomly selected.

RESULTS AND DISCUSSION

The majority of burrow entrances were observed to occur along the cane drill with only a few openings in the aisles between rows. Burrows frequently directly undermined cane stools. In July, 72% of the old burrows and 80% of the new burrows undermined stools. In August, 93 and 87% of the old and new burrows, respectively, undermined stools.

Burrowing activity is summarized in Table 1. In general, burrowing activity increased between March and June, except in Colony 20. Since June, colony size appears to have stabilized with only slight movement into new cane. New burrows appeared each month, but a portion of the old burrows also became inactive, resulting in a relatively constant number of burrow openings each month since June. Although the size of Colony 22 has remained approximately the same as in July, there has been a relatively higher rate of new burrowing in this colony than in the others.

Table 1. Total number of burrows in *Neofiber* colonies during the interval March to September 1976.

	No. burrows				
Colony	March	June	July	August	September
7	74	93(54)[1]	66(9)	60(2)	65(9)
8	4	40(37)	36(3)	34(1)	36(4)
15	18	37(27)	43(11)	40(2)	43(6)
16	18	76(65)	70(10)	63(1)	55(3)
20	17	14(4)	12(0)	12(0)	11(1)
22	19	47(34)	62(20)	60(6)	60(12)
Mean	25.00	51.17(36.83)	48.17(8.83)	44.83(2.00)	45.00(5.83)
SE	10.07	11.68(8.70)	9.07(2.85)	8.18(0.86)	8.10(1.66)

[1] Number of new burrows appearing each month in each colony is given in parentheses.

Variations in burrowing activity between colonies may be due to several factors. Age and/or sex structure of rats that comprise each colony may influence the dynamics of burrowing activity. The length of time each colony has been established in the field and interactions of *Neofiber* with other rat species may also be factors. Further observations and live-trapping in these colonies may reveal reasons for variations.

Unpaired t-tests of data collected in July and August showed significantly more stalks damaged in sample points containing burrows (old and new) than in the control sample points (Table 2). The number of damaged stalks did not vary significantly between new and old burrows in each month.

Table 2. Mean number of sugarcane stalks damaged by gnawing at each sample point.

Month	Control No. stalks [Mean ± SE (%)[1]]	Old burrow No. stalks [Mean ± SE (%)]	New burrow No. stalks [Mean ± SE (%)]
July	0.10 ± 0.07 (0.3)	0.72 ± 0.31[a] (3.7)	2.20 ± 0.88[b] (10.9)
August	0.73 ± 0.18 (2.6)	4.20 ± 0.98[c] (17.1)	3.26 ± 0.61[c] (12.8)

[1] Mean percent of stalks damaged by gnawing at each sample point.
[a] Differs from control ($P<0.10$).
[b] Differs from control ($P<0.05$).
[c] Differs from control ($P<0.01$).

The July mean number of total stalks per control sample point ($\bar{X} = 29.10$) was significantly greater ($P<0.05$) than both the mean number at old burrows ($\bar{X} = 19.24$) and new burrows ($\bar{X} = 20.27$). All stalks, including small sprouts, were included in this count, and it is therefore not necessarily a true representation of the relative numbers of potentially harvestable stalks in each area. In August, sprouts were not counted. No significant difference was detected between burrow and control sample point stalk counts in August (control $\bar{X} = 27.48$; old burrow $\bar{X} = 24.60$; new burrow ($\bar{X} = 25.53$). Further analysis of data for July, August and succeeding months until harvest will be necessary to determine the variability in stalk counts and its effect on the number of damaged stalks.

New burrow counts in July included burrows which had appeared over a 4-month period, whereas August counts included only those made since the previous month's mapping. Therefore, the relative proportion of new to old burrows was high in July and low in August.

It should be noted that the damage to sugarcane near burrows is not necessarily caused solely by *Neofiber*; other rat species probably contribute to this damage.

CONCLUSIONS

The damage was greater around *Neofiber* burrow systems than in control areas during the seventh and eighth months of the growing cycle in the study field. The damage and burrowing will be followed each month until harvest. At that time, it will be determined if the number of millable stalks differs significantly between the burrow and control areas.

As noted earlier, the consumptive or gnawing damage is not the only aspect of *Neofiber* damage. The possible loss of future production of cane stools undermined by burrows should be considered. Therefore, if the field is not replanted, the fate of undermined stools will be determined when the cane resprouts after harvest.

Data on damage related to *Neofiber* colonies, coupled with burrowing, movement, distribution, and reproductive information on this species will be utilized to delineate the impact of *Neofiber* on sugarcane production. The safest and most effective control measures can then be prescribed.

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IMPROVED TWO AND A HALF BOILING SYSTEM

Guillermo Aleman
Glades Sugar House
Bell Glade, Florida

From what we have seen in several sugar processing countries, we still find that the most practical and rewarding processing system for boiling sugar massecuites, as to quality of sugar, recovery and steam consumption, is the so called Two and a Half Boiling System.

First, let us make it clear that we say so called because it is, in fact, a Three Boiling System, only the results are so far apart from those of the conventional Three Boiling System that it deserved a new name, and we seem to recall that in a discussion in a meeting of the Sugar Technologists Association somebody proposed the name considering that in the system there are just two kinds of massecuites: First (A), and Third (C), no Second (B). The specific characteristic are that there are two kinds of First (A): One Virgin (A-1) and one Non-Virgin (A-2).

Based on the above facts, the suggestion made by that particular person was received with enthusiasm by those attending the meeting. In this manner the name was born, and pretty soon it was known as such all over the sugar world.

The advantages of the system are well known, and it is not the intent of this paper to prove them again. They have already been amply discussed and chemically and matehmatically proven in the past.

The concern today is that there is a market for raw sugar of high quality, either for refineries that for one reason or another require such high standards, or, in some other countries, for direct consumption.

In this case, the Two and a Half Boiling System is perfectly ad hoc because, by itself, it permits the production of high quality sugar without hurting the recovery and without requiring any increase in the steam consumed by the vacuum pans.

But, if we still wish, or are required to go beyond what could be called a high quality raw sugar, that is, if we wish or need to produce raw sugar of such a high quality that it would be detrimental to our recovery and/or our steam balance or vacuum pan and centrifugal stations capacity, we can easily go (practically without the addition of any important or expensive equipment) to the Improved Two and a Half Boiling System.

The essential difference is that in this innovation to the original system, the A-2 sugar is washed in the centrifugals up to the point necessary to fulfill the degree of quality required by the new market.

Of course, this washing would raise the purity of the A-2 molasses and consequently the purity of the C massecuite; but this is prevented by separating the real A-2 molasses from the A-2 washings.

Here we have the only equipment that needs to be added, and it is quite simple, inexpensive, easy to install, and easy to operate automatically.

And we would like to emphasize in this case the concept of automatically. For the washing of the sugars in the centrifugals (with the needed compromise between quality of sugar and purity and amount of washing), we cannot depend on human determination.

In the flow-sheet of the system (Fig. 1), we show the modus operandi of the system.

We have not, on purpose, indicated numerical figures, because many of them would depend mainly on the initial purity of the cane juice and the kind of impurities and their relative proportion.

We will start by graining up for 6-C massecuites by full pan seeding on a charge mixture of syrup and molasses of 68-70% purity. After the nucleation has been brought together enough, the pan is then fed with A-1 molasses up to the calculated height for the changing over to A-2 molasses.

The time or height in the vacuum pan for the changing is a function of the purities of the A-1 and A-2 molasses and 58-60% purity desirable in the 6-C massecuites which will be made by cutting over between the pans and the C seed tanks.

The C massecuites are cooled off in the crystallizers in a continuous way. If Workspoor crystallizers are available, so much the better. If not, we can always arrange our crystallizers so that we can accomplish the cooling off in a continuous and steady manner.

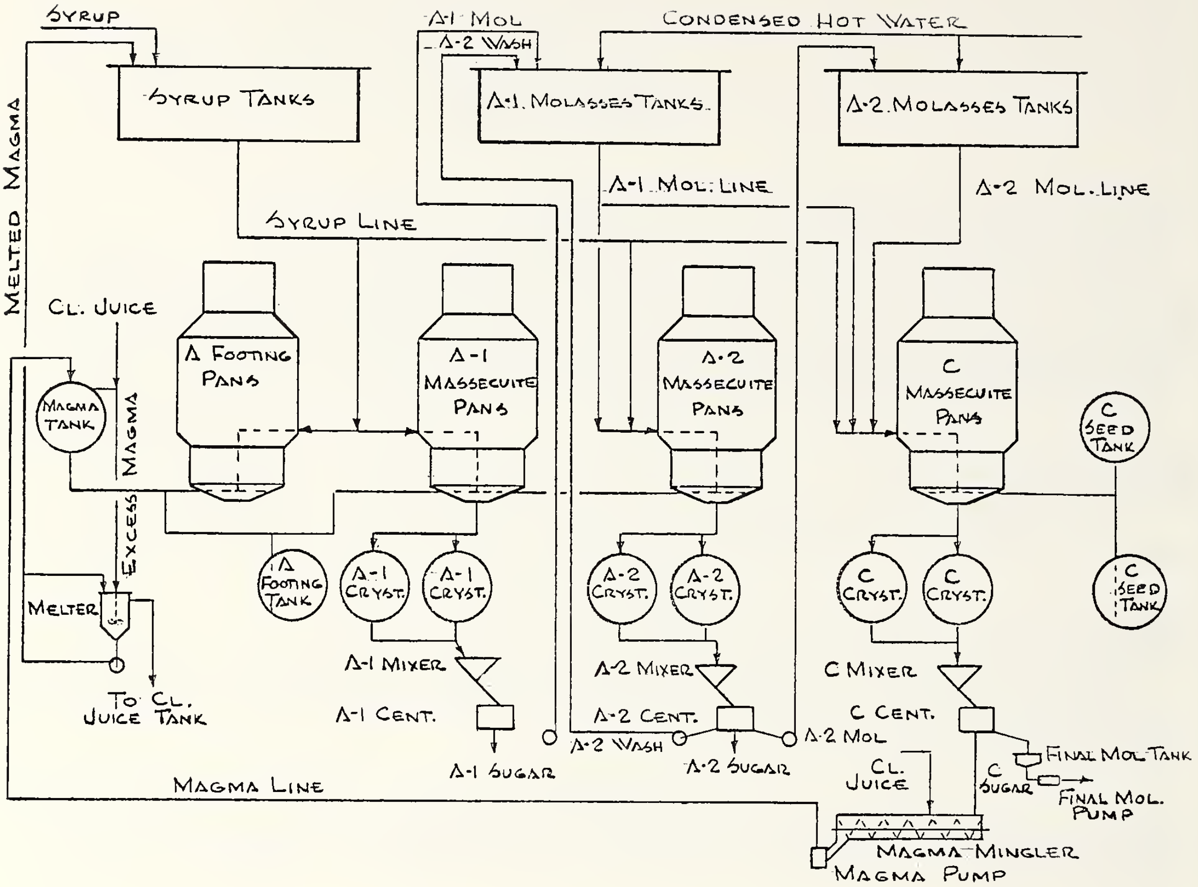

Figure 1. Improved Two and a Half boiling system for the making of high quality sugar while obtaining high sugar recovery.

The C sugar magma is made with clarified juice, the advantage being that hot clarified juice will take care of melting the fine grains that are always produced by grinding in the centrifugals (especially if they are continuous) in the sugar scroll conveyors, in the magma mingler itself, as well as in the magma pump.

Otherwise, these fines would have to be melted in the vacuum pan when charging the magma footings to be developed, thus taking up time and steam.

As you can see in the flow-sheet, the magma tank in the vacuum pan floor has an overflow which falls by gravity into a melter.

Since the C sugar crystals are supposed to be as small and numerous as the C centrifugals permit, a relatively small proportion of the magma is used for footing the A-1 and A-2 massecuites; the excess magma is melted with clarified juice and mixed with the syrup.

Since a large proportion of magma is melted, we have the advantage of purification by recrystallization. Since the magma and the melting are made with clarified juice and not with water, we do not have extra steam consumption other than that represented by evaporating this juice in simple-effect in the vacuum pans instead of in multiple-effect in the evaporators.

The magma is charged into the vacuum pans, which are fed with syrup to develop the crystals, and by means of cutting over between the vacuum pans and the A footing tanks, the crystals reach the proper size for footing A-1 and A-2 massecuites.

The A-1 massecuite, as we said at the beginning (and this is most important to us), is virgin. It's made on a developed magma footing and completed with syrup. Its purity is not controlled; it will depend on the combined purity of the syrup and the C sugar magma. Its brix is about 93.5%.

It is recommended to cool off this massecuite in the crystallizers about 10-12 F; but by forced cooling, that is, in a crystallizer with cooling elements so that the drop in temperature can be achieved in no more than 3 or 4 hours. Otherwise, the sooner you send it to the centrifugals the better.

This massecuite will render commercial raw sugar of highest quality in the centrifugals without requiring much washing. The purity drop between massecuite and molasses will be about 20 or even larger, depending, of course, on how high a quality of sugar is required and whether or not the massecuite was cooled off in the crystallizers before drying. It is not necessary to separate the molasses from the washing.

The A-2 massecuite is made on a footing of developed magma and fed with syrup, magma melt and/or A-1 molasses and A-2 washings.

It is in this massecuite that the purity control of the process is effected to achieve the goal of producing high quality sugar while achieving optimum recovery.

Purity is controlled to that value which will render proper purity in the A-2 molasses to enable C massecuites of 58-60% purity to be made from it. In general, this purity is 77-78, the brix 94-94.5.

This massecuite, after being cooled off 10-12 F in the crystallizers, will render, in the centrifugals, sugar of quality, almost similar. if not the same, as the A-1 massecuite. Of course, it will need more washing in the centrifugal, hence the necessity of separating the molasses from the washing.

If the massecuite is properly handled in the vacuum pans, the purity is 77-78, the brix is 94.5, and it is adequately cooled off in the crystallizers, the A-2 molasses is about 56 purity and the washing is about 66 purity.

The above figures are not estimated, but actually achieved in factories where the process is practiced, including factories producing plantation white for direct consumption.

The washing is sent over to the A-1 molasses tanks to be used as such.

The process for the C massecuites has been described above. The brix should be controlled at about 97.5. The purity and the amount of final molasses will depend, of course, on the nature of the cane juice being dealt with, mainly, the glucose-ash ratio.

We know of a large factory (raw and refinery combined) working with this process where more than 50% of the production is melted and refined. The melt, naturally, has to be of top quality. In this particular case, the A-1 sugar is washed too and the molasses and washings separated. This washing is pumped to the syrup tanks to be used as such. The final molasses in this factory is of 32-33 purity, notwithstanding the fact that the C massecuites are cured in continuous centrifugals, which always produce a final molasses 1.5-2 over the batch machines. The amount of final molasses is 6.5 gal of 88° brix per short ton of cane.

In other factories producing plantation white by sulfitation, 100% for direct consumption, the final molasses is 35-36 purity, mainly due to the fact that they are being operated well above their designed capacity, and most of the time the C massecuite purity is not held between 58 and 60, but many times is 62 and 63. The amount of final molasses is just 5.3 gal of 88° brix per short ton of cane.

In the above three cases, the purity of the juice is 82 in the first case and 85 in the last two.

As a matter of fact, in the case of the factory with refinery, the consumption of steam is 1150-1200 ps/ton of cane ground.

In the cases of the factories making plantation white, the steam consumption is 950-1000 ps/ton of cane.

PAPERS PRESENTED AT 1976 MEETING OF LOUISIANA DIVISION

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RESPONSE OF SUGARCANE TO SUBSURFACE DRAINAGE IN THE FIELD[1]

C. R. Camp and C. E. Carter
USDA, ARS
Baton Rouge, Louisiana

ABSTRACT

Five subsurface-drainage treatments were installed on Mhoon silty clay loam soil to determine yield response of sugarcane to these treatments under field conditions. Two years of data show that subsurface drainage increased sugar and sugarcane yields up to 25 and 28%, respectively. Increased yields in drained plots probably were due to a 20% increase in plant population over that in undrained areas. Yields for the undrained check area decreased from the plant to ratoon crop but remained about the same for the drained plots. Additional data will be required before definite conclusions can be reached regarding the yield response of sugarcane to subsurface drainage under field conditions.

INTRODUCTION

Good surface drainage must be maintained to assure timely field operations and good crop growth on the slowly permeable, alluvial soils of the lower Mississippi Valley. Surface drainage for this region has improved during the past 10 to 15 years with the development and acceptance of precision land grading. The elimination of water ponding in surface depressions allows the surface layers to dry faster and reduces the amount of water infiltrating and moving through the soil profile to the water table. High water tables continue to exist in many soil profiles, however, especially during the winter when rainfall amount and frequency are high and evapotranspiration is low. For annual crops this problem can sometimes be alleviated by delaying spring planting until the water table has fallen to an acceptable level. However, for perennial crops like sugarcane, a high water table during winter and early spring may damage the ratoon crops, since they initiate growth each spring from stubble overwintering in the soil.

Carter and Floyd (3, 4) found that sugarcane yield and longevity in Louisiana increased when the water table was controlled to prevent prolonged saturation in the root zone. These results were obtained on small, concrete-bordered plots where the water table was precisely controlled and excess water in the root zone was removed quickly. Later, Carter and Floyd (5) tested the yield response of sugarcane to high water tables during the dormant season by maintaining the water table 12, 30, and 48 inches below the soil surface only during the growing season (April through November) for 2 years followed by a 2-year period when these three water table levels were maintained during both growing and dormant seasons. During the first 2 years of the experiment, the water table during the dormant season (December through March) was maintained at about 42 inches below the soil surface, and no significant difference in yield was measured among these three water table treatments. When water tables were maintained during both the dormant and growing seasons, the average yield of the second ratoon crop for both the 12- and 30-inch water table treatment was 7.7 tons/acre (17%) less than for the 48-inch water table treatment. During the third ratoon crop, the yields for the 12- and 30-inch water table treatments were 17.7 and 7.1 tons/acre (54 and 22%) less, respectively, than for the 48-inch water treatment.

Field subsurface drainage systems cannot provide the precise control of the water table provided by these small, concrete-bordered plots. However, Camp and Carter (1) found that several subsurface drainage systems installed using commercially available materials and procedures performed well for a Mhoon silty clay loam soil. These systems consist of several drain line depth-spacing combinations that are comparable with those used for farm subsurface drainage. Measurement of sugarcane response to these commercially installed subsurface drainage systems was started in 1973. This paper reports these findings (2 years of data) and provides preliminary analysis of these data.

EXPERIMENTAL PROCEDURE

Various drain line depth-spacing combinations were calculated, using several design equations and a range in parameter values for soil, crop, and climate. From these combinations, the drainage system designs for this experiment were selected using spacings (20, 30, 40, and 80 ft) both narrower and wider than 40 feet, the spacing considered ideal for the selected soil and crop (Table 1). These system designs provided a range of soil-water conditions under which sugarcane growth and response could be evaluated. Additional details regarding design calculations, experimental design, installation procedure, and experimental procedure have been given by Camp and Carter (1).

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[1] Research conducted in cooperation with the Louisiana Agricultural Experiment Station.

The experimental area is about 3 miles north of Houma, Louisiana, on a 25-acre site of Mhoon silty clay loam (sicl) soil. Before drain lines were installed the field was precision graded to surface slopes of 0.15 to 0.20%. All subsurface drainage systems used as treatments, except No. 5, consisted of four parallel, 4-inch-diameter corrugated polyethylene drain lines connected to a 6-inch-diameter main line. The main lines ended in a separate collection symp for each plot. Treatment No. 5 had only three parallel drain lines 2 inches in diameter. Electric, submersible pumps discharged the water from each sump into an adjacent drainage ditch. The plots with subsurface drainage treatments ranged from 1 to 5.6 acres in size, depending upon the number and spacing of drain lines. The check area was precision graded, but had no subsurface drainage. This area (about 1.5 acres) was about 1 mile from the drained area to avoid the influence of the subsurface drainage systems. Areas with and without subsurface drainage will be referred to as drained and undrained areas, respectively, in this paper.

Water table depth was measured weekly in wells installed in selected sugarcane rows in both drained and undrained areas. The wells were cased to a depth of about 4.5 ft with 3/8-inch perforated pipe. Rainfall was measured with a recording-type gauge located adjacent to the drained area.

The experimental area was planted to sugarcane (CP 52-68) in August 1973, and the first crop was harvested in December 1974. The cooperating grower followed normal planting, pesticide, cultivation, and harvesting practices (7). Fertilizer was applied in late April each year at rates of 180, 40, and 80 lb/acre of nitrogen, phosphate (P_2O_5) and potassium (K_2O), respectively. The nitrogen rate was determined by the grower but other rates were based on analyses of soil samples collected each year. Yields for each treatment were determined from 50-ft-long subplots directly over and midway between drain lines at three locations along the rows. Within each subplot, plant population was counted and a sample of 10 stalks was collected for determining juice quality. Sugar per ton of cane was determined for these samples in the laboratory using the procedure described by Legendre (6). All data were analyzed by analysis of variance. Differences among treatments and between treatment and check were determined by Tukey's honestly significant difference (HSD) procedure.

RESULTS AND DISCUSSION

Rainfall for 1974 was 47.3 inches, 18.4 inches below the long-term average for Houma. Weekly rainfall data and water table levels in the undrained check for 1974 are shown in Fig. 1. Rainfall during January, February, and early March was particularly low, resulting in below-average water table levels during the latter part of the sugarcane dormant season. This prevented a good field test on the effects of a high water table on sugarcane yields during the dormant season for the plant crop. Carter and Floyd (5) found that sugarcane was most susceptible to damage by high water tables during the dormant season. Although these water table data are not continuous for the entire year and only weekly measurements were made, the water table in the check area did not seem to rise above about 12 inches below the soil surface at any time during 1974. However, the water table in the check area began falling as soon as rapid sugarcane growth started in the spring, even with frequent rainfall. A relatively low water table level continued through the growing season until September and October when evapotranspiration decreased. No water table data was obtained during November and December because the wells were removed during sugarcane harvest.

Rainfall and water table data in the undrained check for 1975 are shown in Fig. 2. The total rainfall was 71.5 inches, 5.8 inches above the long-term average for this location. During the dormant season preceding this crop year, however, rainfall was lower than for the previous year. Increased rainfall in February and March caused the water table to rise to within 8 inches of the soil surface near the end of March. As sugarcane growth began, the water table fluctuated widely instead of falling as in 1974. These fluctuations persisted throughout the growing season, as the water table rose and fell in response to rainfall. On several occasions the water table was at or very near the soil surface. At harvest, rainfall decreased and the water table fell to 36 inches during November and December.

On the other hand, the water table in all subsurface-drained treatments was at least 42 inches below the soil surface within 4 days after a 4-inch rainfall (1). Lack of continuous measurement prevents definite statements on the maximum water table height, but from experience we can safely say the water table did not remain higher than 24 inches below the soil surface for more than 2 days after heavy rainfall. Further hydraulic data and techniques for evaluating soil hydraulic properties at this site will be reported in another paper.

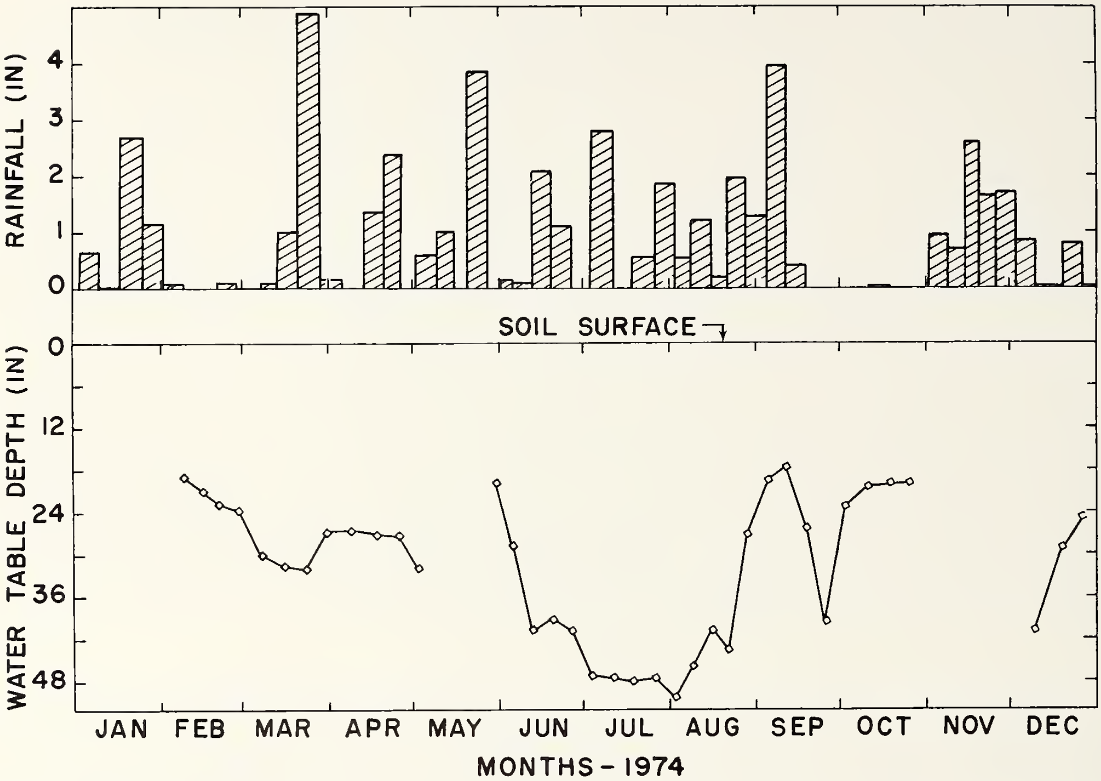

Fig. 1. Weekly rainfall and water table level in the undrained check area at Houma, Louisiana, during 1974.

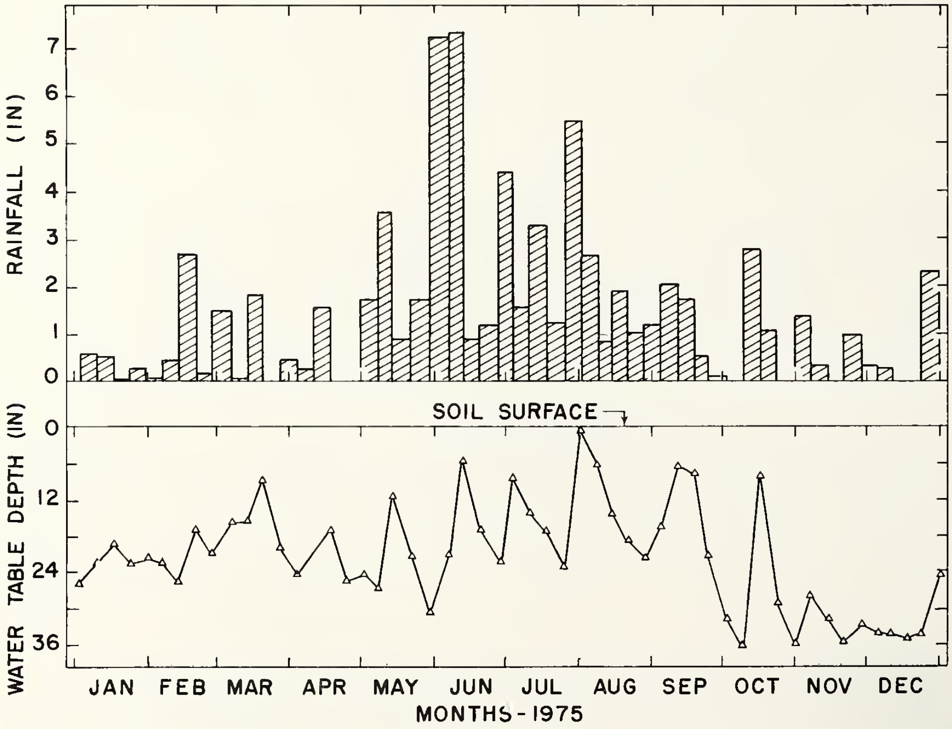

Fig. 2. Weekly rainfall and water table level in the undrained check area at Houma, Louisiana, during 1975.

Plant population, sugarcane yield, sucrose content, and yield of sugar per acre for the plant crop (1974) are given in Table 1 for all treatments. Plant population at harvest for the undrained check area was significantly higher than Treatments Nos. 2, 4, and 5, but was not different from Treatments Nos. 1 and 3. Sugarcane yields, sugar yields, and sucrose content did not differ significantly among treatments or between drained treatments and the undrained check area. In the first ratoon crop (1975) plant population was significantly lower for the undrained check area than for any of the drained treatments (Table 2). Sugarcane and sugar yields were significantly lower for the undrained check and Treatment No. 2 than for other drained treatments. Since measurements indicated Treatment No. 2 was adequately drained, factors other than drainage probably caused this lower yield.

Table 1. Plant population, sugarcane yield, sucrose content, and yield of sugar per acre for plant crop (1974) from various drainage treatments.

Treatment No.	Drain depth (ft)	Drain spacing (ft)	Plant population (stalks/acre)	Sugarcane yield (tons/acre)	Sucrose content (%)	Sugar yield (lb/acre)
1	4.5	40	30200 ab[1]	36.4 a[1]	15.1 a[1]	7740 a[1]
2	3.5	30	28600 b	36.1 a	14.8 a	7510 a
3	4.5 w/spun nylon filter	40	29800 ab	37.9 a	14.3 a	7560 a
4	4.5	80	28200 b	38.5 a	14.6 a	7860 a
5	3	20	28700 b	38.3 a	14.4 a	7740 a
Check	none		34300 a	39.2 a	14.7 a	8080 a
HSD			5400	5.7	0.8	1260

[1] Means in a column followed by the same letter are not significantly different at 5% level according to Tukey's HSD procedure.

Table 2. Plant population, sugarcane yield, sucrose content, and yield of sugar per acre for first ratoon crop (1975) from various drainage treatments.

Treatment No.	Drain depth (ft)	Drain spacing (ft)	Plant population (stalks/acre)	Sugarcane yield (tons/acre)	Sucrose content (%)	Sugar yield (lb/acre)
1	4.5	40	38300 a[1]	37.9 a[1]	16.2 a[1]	8770 a[1]
2	3.5	30	35600 ab	30.4 b	15.5 b	6710 b
3	4.5 w/spun nylon filter	40	38500 a	34.6 a	16.3 a	8030 a
4	4.5	80	36200 ab	35.7 a	16.6 a	8480 a
5	3.5	20	35000 b	36.9 a	16.2 a	8520 a
Check	none		29900 c	29.5 b	16.7 a	7040 b
HSD			3200	3.8	0.6	980

[1] Means in a column followed by the same letter are not significantly different at 5% level according to Tukey's HSD procedure.

Since Treatments Nos. 1 and 4 differed only in drain spacing, these two treatments along with the check area provided a good test of the effects of drain spacing on sugarcane. Although plant population was significantly higher for the undrained check area than for the 80-ft drain spacing for the plant crop, population was significantly lower for the undrained check area than for the two drainage treatments for the first ratoon crop (Table 3). Since an increase in plant population is normally expected between plant and first ratoon crops, the decrease on the check area indicated that it apparently was adversely affected by lack of subsurface drainage before or during the 1975 crop season.

Table 3. Comparison of plant population, sugarcane yield, and sugar yield in plant and first ratoon crops for two drainage treatments (Nos. 1 and 4) and an undrained check area.

Treatment	Plant crop (1974)			First ratoon crop (1975)		
Drain spacing (ft)	Plant population (stalks/acre)	Sugarcane yield (tons/acre)	Sugar yield (lb/acre)	Plant population (stalks/acre)	Sugarcane yield (tons/acre)	Sugar yield (lb/acre)
40	30200 ab[1/]	36.4 a[1/]	7740 a[1/]	38300 a[1/]	37.9 a[1/]	8770 a[1/]
80	28200 b	38.5 a	7860 a	36200 a	35.7 a	8480 a
Check	34300 a	39.2 a	8080 a	29900 b	29.5 b	7040 b
HSD	5400	5.7	1260	3200	3.8	980

1/Means in a column followed by the same letter are not significantly different at the 5% level according to Tukey's HSD procedure.

Sugarcane yields for the 40- and 80-ft drain spacings are compared with yield for the check area in Table 3. Differences between treatments were not significant during the plant crop (1974), but yields for the two drainage treatments were significantly higher than those for the undrained check area during the first ratoon crop (1975). Yields for both drain spacings were about the same each year, but the yield for the check area decreased from the plant to first ratoon crop. Yields for the two drain spacings during the first ratoon crop were 8.4 and 6.2 tons/acre (28 and 21%) higher, respectively, than the yield for the undrained check area.

Results for sugar yield per acre were very similar to the sugarcane yield data, with the 40- and 80-ft drain spacings yielding 1730 and 1440 lb/acre (25 and 20%) more sugar per acre, respectively, than the undrained check area for the first ratoon crop (Table 3).

The water table in the check area was never extremely high during the winter of 1974-75 except for a short period in March, but it was very high during spring and summer, 1975, when the sugarcane was actively growing. While a high water table during the growing season normally does not reduce yield, this particular condition may have been severe enough to do so. Also, the high water table in March may have damaged the germinating buds and adversely affected yield in 1975. This agrees with Carter (2) who found that wet soil during February and March more frequently correlated with reduced cane yields than did wet soil during other months or combination of months during the dormant season. Apparently, the primary cause for reduced yield in the undrained check area was the lower plant population, since sucrose and stalk weight were about equal for all plots.

The effect of subsurface drainage on the growth and yield of sugarcane for this particular soil, sugarcane variety, and climatic condition cannot be conclusively known until yield data for at least one more year are available. However, the data obtained thus far indicate that adequate subsurface drainage may significantly increase sugarcane yield during very wet years.

The final acceptance of any land improvement depends, at least in part, on the costs in relation to expected benefits or increased returns. While the expected monetary benefits cannot be accurately predicted at this time, the anticipated cost of a subsurface drainage system can be estimated for generalized conditions. The depth and spacing of drain lines vary with soil type which will affect the quantity of tubing and installation cost per acre for subsurface drainage. For medium-textured soils such as the Mhoon sicl in this experiment, 80 to 120 ft may be a reasonable drain spacing; however, fine-textured soils such as Sharkey clay may require spacings of 20 to 40 ft. Estimated costs for installing subsurface drainage without a filter and with an outlet provided are shown in Table 4 for several drain spacings and a range of installation price rates. Since drainage contractors have not been active in Louisiana, it is difficult to estimate the installation price rate, but $0.60/ft of line appears to be a reasonable estimate. Based on this rate and drain spacings of 20 to 120 ft, the cost of installing subsurface drainage on one acre can range from about $200 to $1300, depending primarily upon soil type (Table 4). Clearly, increased economic returns from this land improvement will have to be realized before it will be widely accepted. However, the economic benefits of improved drainage may change drastically if the overall production management system (and attendant cultural practices) for sugarcane in Louisiana should change so that better drainage is required to obtain optimum or even acceptable yields.

Table 4. Subsurface drainage installation cost per acre for various spacings and installation prices.

Drain line spacing (ft)	Length of drain line per acre (ft/acre)	Drain installation cost				
		Material and installation price rate ($/lin. ft)				
		.40	.50	.60	.80	1.00
		($/acre)				
20	2178	871	1089	1307	1742	2178
40	1089	436	544	653	871	1089
80	544	218	272	326	435	544
120	363	145	182	218	290	363
160	272	109	136	163	218	272

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POTENTIAL FOR REGULATING GROWTH OF LOUISIANA SUGARCANE

F. A. Martin
Louisiana Agricultural Experiment Station
Baton Rouge, LA

ABSTRACT

In nature, plant growth is controlled by the environment and the genetic make up of the plant. This natural control is mediated through the balance of at least four general classes of plant growth regulators: auxins, gibberillins, cytokinins, and growth inhibitors. Man, through agriculture, has traditionally manipulated his crop or the immediate environment to achieve a particular growth response. Pruning, clipping, fertilization, irrigation, and plant breeding are only a few agronomic means of regulating plant growth. Most of these practices are labor and/or energy intensive and therefore expensive. Consequently the idea of developing synthetic growth regulators is becoming increasingly popular. The earliest, most successful agricultural application of plant growth regulator technology was in the field of weed control. This area of agricultural science has developed only because of the commitment of agricultural chemical industries and the land grant universities. It is apparent that there exist an equal potential for chemical regulation of crop growth. Application of basic information should yield technologically feasible chemical crop growth regulators which will be used to achieve desired growth responses. The rate of development of this technology, however, will be proportional to the degree of commitment of the agricultural chemical industries and land grant universities toward this goal.

THE FUEL AND STEAM BALANCE IN THE RAW SUGAR FACTORY

Harold S. Birkett
Baton Rouge, La.

ABSTRACT

This paper presents the fuel and steam balances (live and exhaust steam) applicable to Louisiana conditions as a function of the live-steam generation-pressure and degree of superheat. It is shown that an increase in the live-steam pressure and superheat would be required to eliminate the present dependency of Louisiana sugar factories on natural gas and other supplementary fuels. At present, about 50% of the steam generated by Louisiana sugar mills is from natural gas. The installation of air preheaters and/or bagasse dryers could reduce the present dependency on supplementary fuels by about half; however, further basic changes in the factory design will be required to entirely eliminate the need for supplementary fuels. The results indicate that the quantity of live steam required to operate factories can be greatly reduced by raising the live-steam generation-pressure and superheat. The study includes live-steam generation conditions from 150 psig, saturated, to 700 psig, with 250 F superheat. It is shown that at the higher live steam pressures the quantity of steam required would be reduced sufficiently so that all steam requirements could be obtained from the available bagasse. At the proposed higher live-steam pressures, the reduced live steam produced would result in a proportional reduction in the available exhaust. Eight different evaporation schemes are presented, and it is shown that more efficient evaporation schemes are available which require no more exhaust than is available.

INTRODUCTION

The rapid increase in the costs of manufacturing sugar makes it imperative for sugar factories in Louisiana to eliminate or reduce the supplemental fuel they burn. The worldwide shortage of fossil fuels lends emphasis to this. This article is written primarily with Louisiana conditions in mind. However, since it presents a simple graphical method for the design, improvement, and evaluation of the fuel and steam balances in raw sugar factories in general, it may be of wider interest.

Ideally, a raw sugar factory should be designed to have a 5 to 10% surplus of bagasse to provide fuel for operations outside of normal running, such as unplanned stoppages, cleaning, and boil-off periods. However, at factories having no use for excess bagasse, steam economy should not be carried so far as to produce a large bagasse surplus which would present a disposal problem and increase costs.

Any estimation of the requirements in equipment and operating conditions necessary to obtain a fuel and steam balance using only bagasse as fuel is an exercise that should be specific for each factory. The accuracy of such estimates will naturally depend on the accuracy of the available data. The major data required are:

1. The composition of the cane processed. In particular, the pol and true fiber contents as well as the purity of the juice are required. Since the cane milled in Louisiana today contains varying amounts of soil, the usual factory chemical control data do not allow an accurate estimation of the true cane fiber. However, if the ash content of the bagasse is determined in addition to the usual determinations of water and nonsucrose solids, a reasonable approximation of the true fiber is obtainable.

2. The operating conditions that prevail at the factory. The quantity of imbibition water applied is required since this is related to the quantity of mixed juice processed and the evaporation required. The evaporator scheme employed has a great influence on the exhaust required by the boiling house.

3. The pan boiling scheme and boiling house recovery. From these data the quantity of steam required for boiling the various massecuites can be estimated.

4. The average steam consumption of the various prime movers and ancillary steam-using units. In designing new factories, the degree of efficiency in steam utilization by the prime movers can be obtained from a trial calculation of the fuel and steam balances for the conditions that prevail. However, in improving the fuel balance of existing factories most of the equipment installed as prime movers must be retained in order to keep capital expenditure to a minimum. In such factories, it is desirable to install, if not already present, a steam meter to ascertain the quantity of steam (lb/hr) delivered by the boilers to the factory. A second steam meter should be installed in the live steam make-up to exhaust line. From these data the quantity of steam delivered to the prime movers and ancillary equipment is obtainable.

Efficiency in steam generation and usage requires consideration of the following:

1. The adoption of efficient methods of steam generation, the use of higher steam pressures than have been conventional in Louisiana factories, the use of superheat and, if necessary, the employment of air preheaters, bagasse driers and/or economizers to recover waste heat from the flue gases and improve the efficiency of the bagasse burning.

2. The use of steam-efficient prime movers.

3. The adoption of evaporator schemes that permit high steam economy, by increasing the number of effects and/or employing vapor bleeding and/or vapor recompression.

4. Cleaner cane and improved milling to obtain lower moisture contents to improve bagasse combustion efficiency and net heating value.

SCOPE OF THE PAPER

This paper covers the areas of:

Live Steam Availability: For specified conditions of cane and bagasse quality and furnace and boiler operating conditions, the steam availability per ton of cane is determined (Table 1 and Fig. 1).

Live Steam Required: For assumed high pressure steam conditions and prime mover requirements and specifications, the live steam requirements are determined (Table 3 and Fig. 2).

Fig. 3 is a combination of Fig. 1 (Steam Available) and Fig. 3 (Steam Required).

Exhaust Steam Availability: For specified high pressure steam conditions and production, the corresponding available exhaust steam is determined (Table 5 and Fig. 4).

Particular Louisiana Factory Process Exhaust Steam Requirements: Exhaust steam requirements are calculated using different evaporator schemes to include the number of effects, the addition of pre-evaporators, and the practice of vapor bleeding or vapor robbing (Table 6 and Fig. 5).

Live and Exhaust Steam Production and Requirements: The preceeding data are consolidated into a single graphical presentation to show the corresponding high pressure and exhaust steam availability and requirements.

The basic calculations utilized in preparing the graphical data are shown below:

Potential Live Steam Available from Bagasse:

$$\text{Bagasse \% cane} = \frac{\text{fiber \% cane}}{\text{fiber \% bagasse}} \times 100$$

Taking the gross heating value of dry, ash-free bagasse as 8350 Btu/lb, the potential live steam generation per ton gross cane will be:

$$\frac{8350 \times \frac{\text{fiber \% cane}}{\text{fiber \% bagasse}} \times 100 \times \frac{2000}{100} \left[1 - \frac{\text{moisture \% bagasse}}{100} - \frac{\text{ash \% bagasse}}{100} \right] \times \frac{\text{boiler efficiency}}{100}}{\text{heat required to generate 1 lb of live steam}}$$

where: heat required to generate 1 lb steam = enthalpy of live steam - enthalpy of boiler feed water.

TOTAL LIVE STEAM REQUIREMENTS OF THE FACTORY

The live steam requirements are calculated from the prime mover horsepower requirements and their respective water rates. The prime movers are the engine or turbines driving the knives, the mills, screw presses, shredders, turbo-generators, induced draft fans, injection water pumps, etc. Some live steam is also required for exhaust make-up vacuum ejectors, steam cleaning, and miscellaneous services.

In general, the horsepower requirements are determined by the number of cane preparation and milling units and the tons of fiber passed per hour by the mills. The water rates of the prime movers are dependent on their efficiency and the live steam and exhaust conditions. The turbine water rates decrease with increasing turbine efficiency, increasing live steam pressure and/or superheat, and decreasing exhaust pressures and vice versa. The exact dependency of water rate on the live steam and exhaust conditions can be obtained from the Mollier Chart assuming isentropic operation.

EXHAUST STEAM AVAILABLE

All live steam that goes through the prime movers produces exhaust steam. Under saturated live steam conditions the exhaust will be partially condensed, i.e. be less than 100% quality. The exact quality can be obtained from the Mollier Chart using the live steam conditions and exhaust pressure, together with the thermodynamic efficiency of the prime movers. Radiation heat losses will somewhat lower the exhaust steam quality between the prime movers and the exhaust users, and this effect can be estimated.

In the case of a relatively large (more than 150 F) live steam superheat, the exhaust will still be superheated, and can thus be desuperheated with water to form more exhaust than the live steam that went through the turbine.

EXHAUST STEAM REQUIRED FOR PROCESSING

The exhaust steam requirements include those of the evaporators, juice heaters, the pans, and the boiler feed water deaerators. Exhaust may also be utilized for air-preheaters, massecuite reheating and other miscellaneous uses.

The evaporator scheme selected greatly influences the total exhaust requirements of the raw sugar factory.

To determine the exhaust requirements of the heaters and evaporators, a detailed heat balance is required. The exhaust (or vapor) requirement for the pans is usually obtained by calculating the evaporation performed by the pans and multiplying this value by a pan factor (1.15 to 1.25) depending on the grade of strike boiled.

BASIC ASSUMPTIONS AND CALCULATIONS

Preparation of the graphical material is demonstrated in the following calculations using basic data typical of Louisiana conditions.

Cane,	% pol	= 10.00
	% fiber (apparent)*	= 15.00
	% mixed juice	= 90.00
Imbibition	% cane	= 23.71
Bagasse,	% moisture	= 51.00
	% fiber + ash	= 44.50
	% fiber	= 35.60
	% ash (including field soil)	= 8.90
	% cane	= 33.71
Mixed juice,	% pol	= 10.00
	% brix	= 12.66
	purity	= 79.00
Boiler efficiency, %		= 44.00
Prime movers, HP		= 25 HP - Hr/Ton Cane
Turbo-generator, KW		= 9.6 KW Hr/Ton Cane
Miscellaneous live steam		= 60 lb/Ton Cane
Boiler feed water temp., °F		= 250

POTENTIAL LIVE STEAM FROM BAGASSE

$$\text{Potential steam/gross ton cane} = \frac{8350 \times \frac{15.00}{44.55} \times 100 \times \frac{2000}{100}\left[1 - \frac{51.00}{100} - \frac{8.90}{100}\right] \times \frac{44}{100}}{\text{heat required to generate 1 lb steam}}$$

$$= \frac{1{,}241{,}523}{\text{heat required to generate 1 lb steam, Btu/lb}}$$

Table 1 and Fig. 1 show the potential live steam available at 15, 16.9, and 18.75% apparent fiber in cane (12, 13.5, and 15% true fiber in cane) as a function of the live steam conditions assuming a boiler feed water temperature of 250 F.

Table 1. Potential live steam available, lb steam/gross ton cane

Live steam conditions			Lb steam/gross ton cane		
			True fiber % cane		
Pressure, psig	°FSH	Enthalpy Btu/lb	12	13.5	15
150	0	1196.1	1015	1142	1269
250	100	1266.1	948	1067	1185
400	150	1304.8	914	1028	1142
550	200	1341.6	884	995	1105
700	250	1376.3	858	965	1072

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*Apparent fiber is defined as true sugar cane fiber plus extraneous insoluble dry solids.

Table 2 shows the turbine water rates applicable to the live steam conditions considered. The water rates are calculated from

$$\text{water rate, lb live steam/h.p.-hr} = \frac{\dfrac{2545}{H_2-H_1}}{\text{(thermodynamic turbine efficiency)/100}}$$

H_2 is the enthalpy of the inlet live steam, Btu/lb
H_1 is the isentropic exhaust enthalpy at 15 psig
(from the Mollier chart), Btu/lb

Table 2. Calculated water rates of steam turbines.

Live steam conditions	Isentropic H_2-H_1 Btu/lb	Turbine water rate, lb steam/hp-hr	Turbo-generator water rate, lb steam/KW-hr
150 psig, 0°FSH	129.1	39.4	40.9
250 psig, 100°FSH	179.1	28.4	29.5
400 psig, 150°FSH	224.8	22.6	23.5
550 psig, 200°FSH	257.6	19.8	20.5
700 psig, 250°FSH	288.3	17.7	18.3

The prime mover turbines (with the exception of the turbo-generator drive) are assumed to be single-stage with a thermodynamic efficiency of 50%. The turbine driving the generator is assumed to be a multi-stage with a thermodynamic efficiency of 68%. The efficiency of the generator itself is taken as 95%.

In most Louisiana raw sugar factories the exhaust pressure is usually between 10-15 psig. An exhaust pressure of 15 psig has been assumed in this paper so that vapor bleeding will be practical. An exhaust pressure of 15 psig represents a reasonable compromise between turbine water rates and boiling house heating surface requirements.

The total live steam requirements for the prime movers and turbo-generator are obtained by multiplying the power requirement (hp-hr/ton cane or KWH/ton cane) by the appropriate water rate. The total live steam requirement is obtained by combining the prime movers and turbo-generator requirements with the miscellaneous live steam requirement (assumed to be 60 lb/ton cane), as shown in Table 3.

Table 3. Live steam requirements for prime movers and miscellaneous lb live steam/ton cane.

Cane	Live steam conditions 150 psig, 0°FSH	250 psig, 100°FSH	400 psig, 150°FSH	550 psig, 200°FSH	700 psig, 250°FSH
Prime movers (25 hp-hr/ton cane)	985	710	565	495	443
Turbo-generator (9.6KWH/ton cane)	393	283	226	197	176
Miscellaneous	60	60	60	60	60
Total live steam	1438	1053	851	752	679

In general, the exhaust steam from a turbine is less superheated than the entering live steam. In the case of saturated live steam to a turbine, the turbine's exhaust is partially condensed, and the weight of saturated steam available is less than that of the live steam entering the turbine. In the case of moderately superheated live steam to a turbine the turbine's exhaust may still be superheated, in which case it can be desuperheated with water to yield a greater weight of saturated exhaust than that of the live steam entering the turbine. Table 4 shows the saturated exhaust available per lb of live steam used by the turbines as a function of the live steam condition at the turbine efficiencies assumed.

The quantity of saturated exhaust steam available can be obtained by multiplying the live steam used by the turbines by the pounds of saturated exhaust available per pound of live steam used by the turbines. This is given in Table 5.

Table 4. Lb exhaust available per lb live steam used by turbines.

Live steam conditions	Enthalpy of live steam, H_1, Btu/lb	15 psig isentropic exhaust enthalpy, H_2 Btu/lb	H_2-H_1 Btu/lb	Turbine exhaust enthalpy calculated from weighted average thermodynamic turbine efficiency, Btu/lb	Saturated exhaust available at 100% quality per lb live steam
150 psig, 0°FSH	1196.1	1067	129.1	1124.9	0.966
250 psig, 100°FSH	1266.1	1087	179.1	1167.4	1.003
400 psig, 150°FSH	1304.8	1080	224.8	1180.8	1.014
550 psig, 200°FSH	1341.6	1084	257.6	1199.6	1.031
700 psig, 250°FSH	1376.3	1088	288.3	1217.4	1.046

Table 5. Saturated exhaust steam available from turbines, lb saturated exhaust/ton cane.

Live steam conditions	Live steam used in turbines lb/ton cane	Exhaust available per lb live steam used in turbine	Exhaust available at 100% quality, lb/ton cane
150 psig, 0°FSH	1378	0.966	1331
250 psig, 100°FSH	993	1.003	996
400 psig, 150°FSH	791	1.014	802
550 psig, 200°FSH	692	1.031	713
700 psig, 250°FSH	619	1.046	647

The exhaust requirements of a sugar factory are dependent on several factors such as quality of juice, evaporation scheme employed, sugar boiling scheme selected, etc. For the juice quality assumed, the use of the conventional three boiling (A, B, C) pan scheme, and various evaporator configurations, the exhaust requirements have been rigorously calculated and the results are presented in Table 6.

Table 6. Typical Louisiana factory process exhaust steam requirements for various evaporation schemes.

	Various evaporation schemes* Lb steam/100 tons cane							
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Pre-evaporator	--	--	29,729	56,462	--	56,462	--	--
Evaporator	51,022	39,416	35,756	27,184	83,337	20,013	76,474	72,654
Limed juice heater	23,004	23,004	--	--	--	--	--	--
Clarified juice heater	4,424	4,424	--	--	--	--	--	--
Vacuum plans (theoretical average)	26,481	26,481	26,481	--	--	--	--	--
B. F. W. deaerator	7,530	7,530	7,530	7,530	7,530	7,530	7,530	7,530
Total	112,461	100,855	99,496	91,176	90,867	84,005	84,004	80,184
Average req'd., lb exhaust/ton cane	1,125	1,009	995	912	909	840	840	802

*For description of evaporator schemes, see Figure 8.

DISCUSSION OF GRAPHS

Fig. 1 (data from Table 1) shows the relatively small decline in the potential steam production as the live steam pressure and superheat are increased.

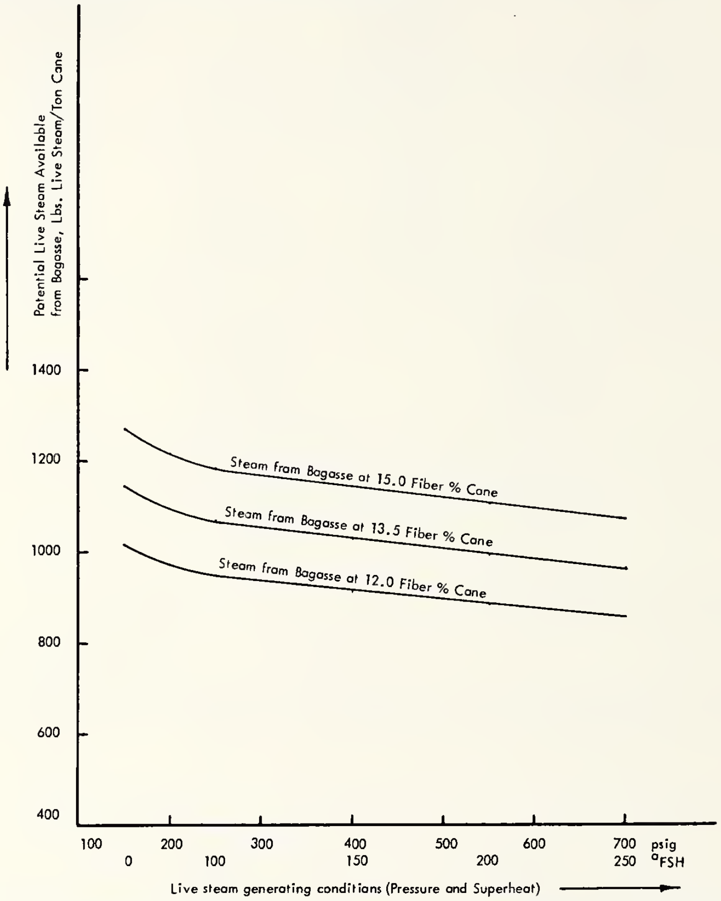

Fig. 1. Potential live steam available, lb/ton cane, as a function of true fiber % cane and live steam generating conditions (pressure and superheat). Assumptions: Boiler feed water temperature of 25C F; moisture % bagasse of 51.0%; boiler efficiency of 44.0%.

Fig. 2 (data from Table 2) shows the substantial reduction in the live steam required (prime movers, and miscellaneous but excluding make-up to exhaust) for the factory as the live steam pressure and superheat are increased. The reason for this is that virtually all of the additional heat supplied to the live steam in raising its pressure and temperature is available for conversion into work by the turbines. The isentropic exhaust enthalpy (heat content) is virtually unchanged as the live steam pressure and temperature to the turbines increases. However, because the turbines are not ideal turbines, in practice the exhaust enthalpy increases as the live steam pressure and temperature increases. Nevertheless, the fraction of the total live steam enthalpy that the turbines extract (convert into work) increases rapidly as the live steam pressure and temperature increases.

Fig. 3 is a combination plot of Fig. 1 and Fig. 2, and thus represents the live steam available and the live steam required. Fig. 3 is thus a graphical live steam balance for various live steam pressures and superheat. In Fig. 3 the minimum live steam pressure and temperature required for an energy-sufficient operation is readily determined for any fiber per cent cane value simply by noting where the available live steam line intersects the live steam requirement line, i.e. the breakeven point. Thus, for a fiber percent cane value of 12% the minimum live steam conditions are about 330 psig with 125 F superheat. Under these conditions the potential live steam available is 940 lb/ton cane, and the live steam required is also 940 lb/ton cane. From a practical standpoint, a higher pressure and temperature should be selected so that the potential live steam available is greater than the live steam requirements, thus permitting some bagasse to be stored while only burning that quantity of bagasse necessary to operate the factory. Clearly, at live steam pressures below the breakeven point, the factory live steam requirement cannot be met entirely from the available bagasse fuel and some supplementary fuel will be required. The magnitude of this live steam deficit can be obtained by drawing a vertical line on Fig. 3 through the live steam pressure and obtaining the difference between the live steam required and the potential live steam available. Similarly, for steam pressures above the breakeven pressure, the magnitude of the potential excess live steam can be obtained.

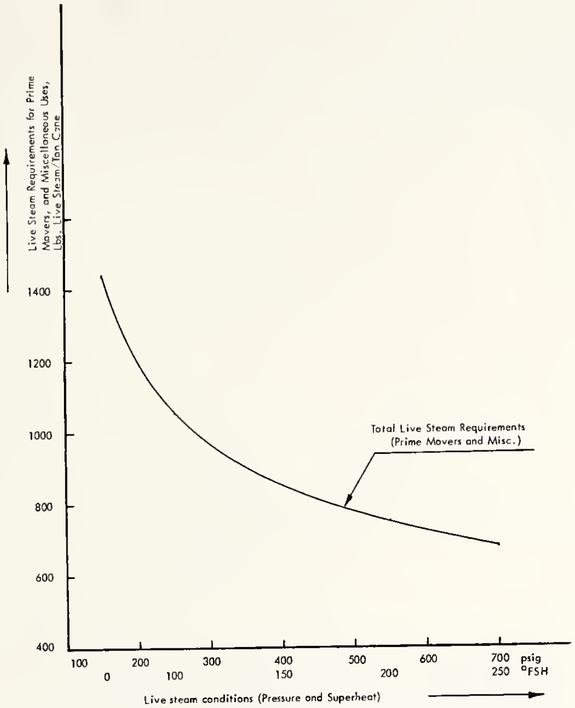

Fig. 2. Factory prime movers, turbo-generator, and miscellaneous live steam requirements (excluding make-up to exhaust) as a function of live steam conditions (pressure and superheat). Assumptions: Prime movers require 25 H.P./ton cane; turbo-generator load of 9.6 KWH/ton cane; misc. live steam usage of 60 lb/ton cane; prime mover thermodynamic efficiency of 50%; turbo-generator turbine thermodynamic efficiency of 68%; turbo-generator electrical efficiency of 95%; exhaust pressure of 15 psig.

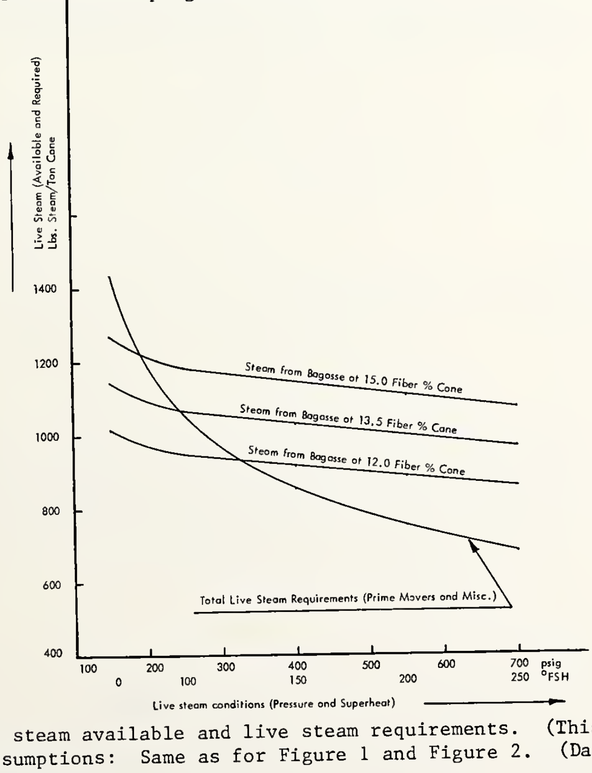

Fig. 3. Potential live steam available and live steam requirements. (This figure combines Figure 1 and Figure 2). Assumptions: Same as for Figure 1 and Figure 2. (Data taken from Table 1 and Table 3).

Fig. 4 (data from Table 5) shows the saturated exhaust available from the turbines at various live steam pressures.

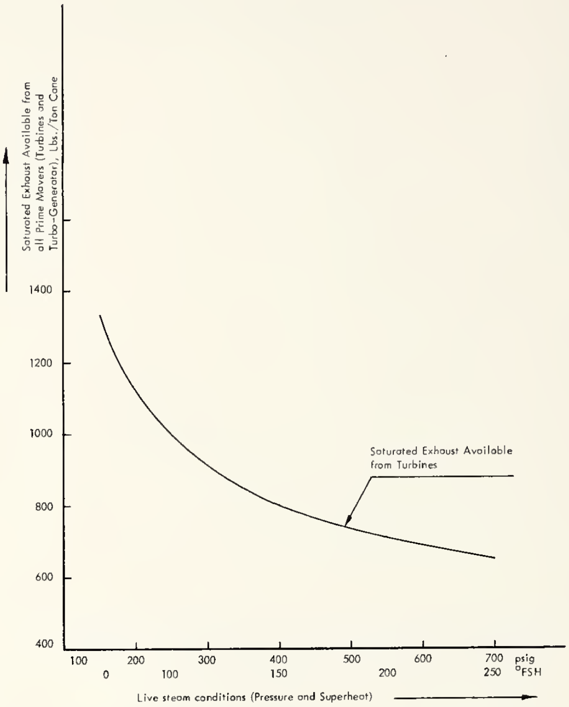

Fig. 4. Saturated exhaust available from turbines as a function of live steam pressure and superheat to turbines. Assumptions: Same as Figure 2; no heat loss; turbine exhaust desuperheated to saturation.

Fig. 5 (data from Table 6) shows the total saturated exhaust required for the boiling house for eight different evaporator schemes. The saturated exhaust requirement does not depend on the live steam conditions, and thus these lines are all horizontal.

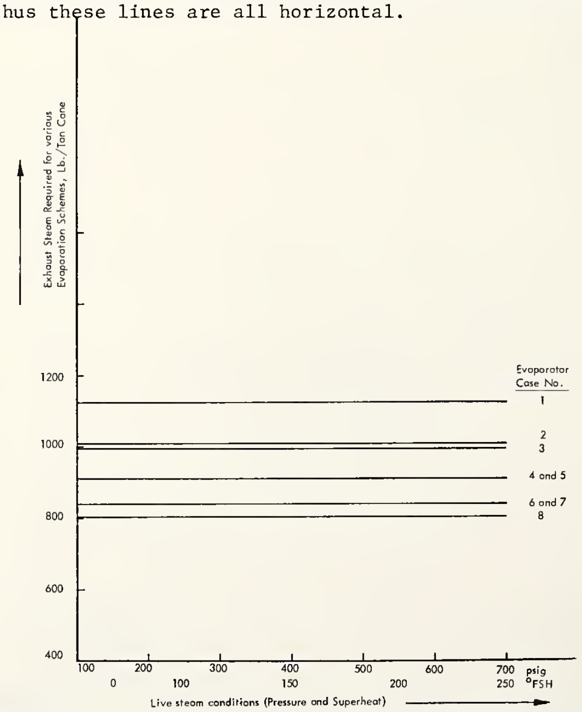

Fig. 5. Exhaust steam requirements for various evaporation schemes as a function of live steam conditions (pressure and superheat). Note: Exhaust steam requirements are independent of live steam conditions. For description of Evaporator Schemes see Figure 8.

Fig. 6 is a combination plot of Fig. 4 and Fig. 5 and thus represents the exhaust steam available and the exhaust steam required. Fig. 6 is thus a graphical exhaust steam balance for various live steam pressures and evaporator schemes. The interpretation of this plot parallels that of Figure 3. The breakeven point for any evaporation scheme is located at the live steam conditions where the exhaust required by the given evaporation scheme intersects the available exhaust line. Below the breakeven steam pressure there will be excess exhaust, while above the breakeven pressure there will be an exhaust deficit which will have to be made up by reducing (and possibly de-superheating) live steam. From a practical standpoint the actual exhaust requirement periodically exceeds the average values plotted due to the cyclic nature of the vacuum pan operations.

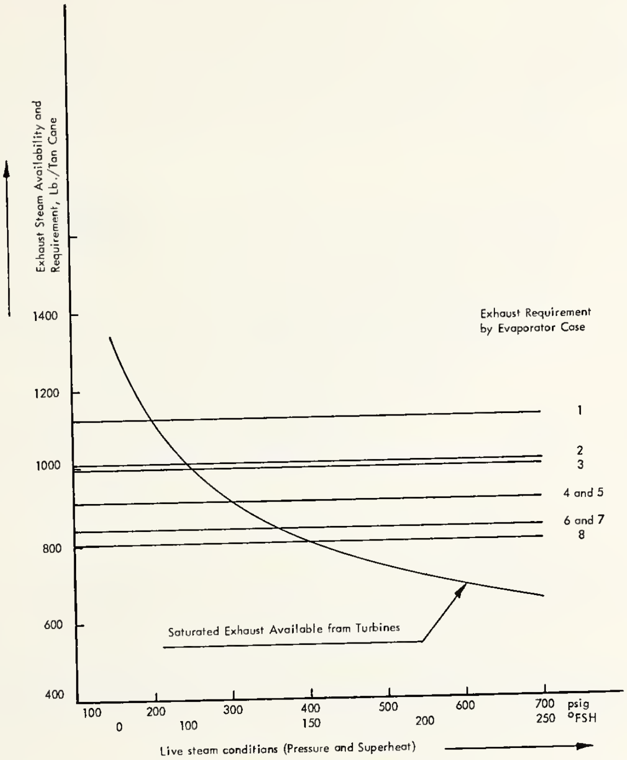

Fig. 6. Exhaust availability and requirements as a function of live steam conditions (pressure and superheat). (This figure is a combination of Figure 4 and Figure 5).

In a properly designed sugar factory not utilizing excess bagasse for sale or as a raw material, the following conditions should be satisfied:

1. The total live steam requirement should not exceed the live steam available from the bagasse.
2. The exhaust required for processing operations should not exceed the exhaust available from the turbines. It is permissible, and sometimes desirable, for the exhaust requirement to exceed the exhaust available from the turbines provided that there is adequate live steam available to make-up the difference.

In designing a sugar factory to meet the above requirements it is helpful to combine Fig. 3 and Fig. 6 in a single plot as in Fig. 7. Fig. 7 thus graphically presents the live steam balance and the exahust steam balance as a function of the live steam pressure and evaporator scheme. In this form the inter-relationship between the live steam balance and the exhaust steam balance can be conveniently studied and used to select appropriate steam generating conditions and evaporator schemes, as exemplified in the subsequent discussion on steam pressures and superheat.

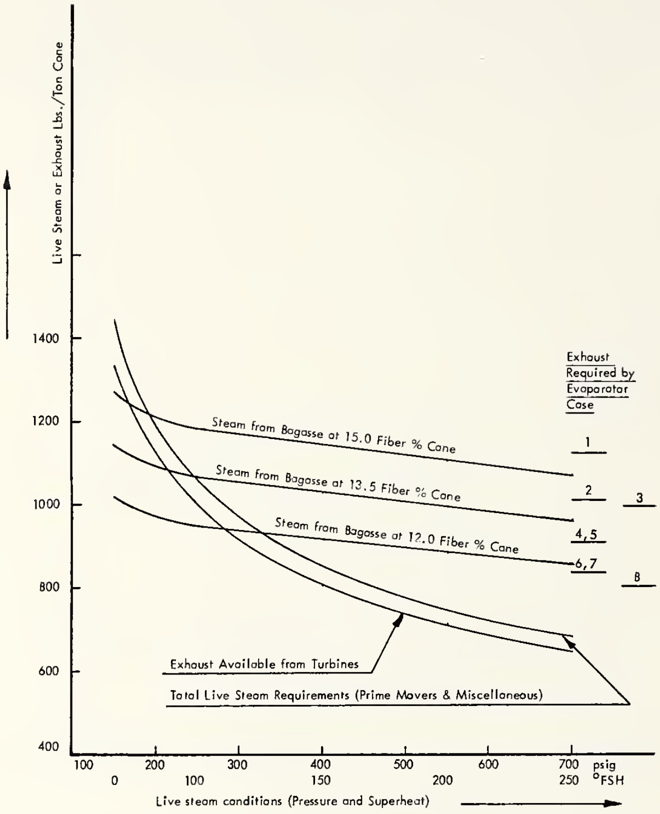

Fig. 7. Potential live steam generation, live steam requirement, exhaust availability, and exhaust requirement as a function of: 1. Fiber % cane, 2. Live steam conditions (pressure and superheat), 3. Evaporation scheme. Assumptions: Same as for Figures 1, 2, 4, and 5.

THE CASE FOR HIGHER PRESSURE BOILERS

The preceding discussion and basic calculations are applied below in a comparison of low and medium pressure boiler installations.

Two cases will be considered:

1. Live steam generated at 150 psig, saturated.
2. Live steam generated at 400 psig, 150°FSH.

In Louisiana, the true fiber % cane averages about 12%. The reported fiber % cane values of 15-17% reflect large quantities of field soil (ash producing) in the bagasse, and includes chemical control errors resulting from inaccurate weights. Milling tests on clean cane at the Audubon Sugar Factory, Louisiana State University, as well as direct cane analysis using the core sampling method on clean cane consistently yield fiber % cane values of 10-14%. Bagasse from several commercial factories has been analyzed for ash (primarily field soil), and after deducting this ash from the fiber % bagasse reported by the factories, the true fiber % cane is about 11-14%. The steam available from bagasse is directly proportional to the true (cane) fiber in bagasse and the pol in bagasse--the field soil (ash) being incombustible. A true fiber % cane value of 12 is used throughout the following discussion. Small changes in the true fiber % cane have a marked influence on the minimum live steam pressure required for fuel self-sufficiency.

Case 1. 150 psig, saturated steam: From Fig. 7 (also Table 3), the total live steam required is 1438 lb/ton cane. Fig. 7 (also Table 1) shows that only 1015 lb steam/ton cane can be generated from bagasse, the deficit of 423 lb steam/ton cane (30% of the total steam requirement) will have to be made up by use of either supplementary fuel or purchased electric power. If the factory does not have a turbo-generator and purchases electric power, the total live steam requirement will be 1045/lb ton cane (see Table 4); however, this will only produce 955 lb exhaust/ton cane. The most common Louisiana sugar factory evaporation schemes (Cases 1, 2, and 3) all require more exhaust than 955 lb/ton cane, and thus supplementary fuel is still required in the factory to produce live steam for make-up to exhaust for the boiling house.

Case 2. 400 psig, 150°FSH steam: At this live steam pressure 914 lb steam/ton cane cane be generated, while only 851 lb steam/ton cane is required. The 851 lb steam/ton cane will produce 802 lb exhaust/ton cane which would be just adequate for the most efficient evaporation scheme considered (Case 8). Since 851 lb steam/ton cane is generated while 914 lb/ton cane is potentially available, there is an excess steam potential of 63 lb/ton cane. If this additional 63 lb/ton cane of steam is not generated, then 6.9% of the bagasse produced can be stored for use during non-grinding periods (breakdowns, boil-off, cleaning, etc.).

Case 1 represents the operation at most Louisiana factories. Case 2 projects an alternative that will solve the energy requirements of a typical Louisiana factory. The implications of this analysis is that for the average Louisiana raw sugar factory to be energy sulf-sufficient it will have to:

1. Increase boiler operating conditions to about 400 psig, 150°FSH.
2. Utilize more efficient evaporator schemes, i.e. robbed quadruple effect evaporators instead of triple effects.

Less extreme modifications to the steam generation plant, installed prime movers, and the evaporation scheme may bring individual factories into or close to fuel balance if:

1. The boiler efficiency can be upgraded from the very low average value of 44% to an efficiency greater than 55%.
2. The true fiber in cane is greater than the 12% assumed.
3. The prime mover horse-power can be reduced.

However, it can be seen that it will be impossible to achieve fuel self sufficiency with the 150 psig saturated steam still used in many Louisiana factories. It would seem that 250 psig, 100°SH would be the minimum steam conditions that can be considered under any Louisiana conditions if fuel self-sufficiency is to be achieved, and that substantially higher steam pressures and temperatures will often be required.

Individual factories should critically evaluate their steam balance to develop long range plans for bringing the factory energy requirements into balance with the available energy in bagasse. Large capital investments for new boilers, high pressure prime movers, and turbo-generators, etc. may not be justified immediately. However, with normal replacement or expansion the factory can be converted to the desired arrangement in phases. Careful planning is required so that each intermediate phase represents an improvement. Particular attention should be given to:

1. Obtaining cleaner cane, and installing efficient cane washing tables. Cleaner cane results in lower mill wear (lower bagasse moisture), less field soil in bagasse, and better bagasse burning properties.
2. Improving boiler efficiency with air-preheaters, economizers, deaerators, bagasse driers, and improved instrumentation.
3. The reduction in prime-mover live steam consumption with increasing pressure and superheat of the live steam, and increased turbine stages. (Careful consideration must be given to the quality of condensate and boiler make-up waters as steampressure and temperature are increased).
4. The reduction in exhaust consumption possible with alterations to the evaporator scheme.

The reduced cost for supplementary fuel as a result of reduced supplementary fuel requirement may offset the capital costs incurred by the improvements, but each case will require investigation and careful planning.

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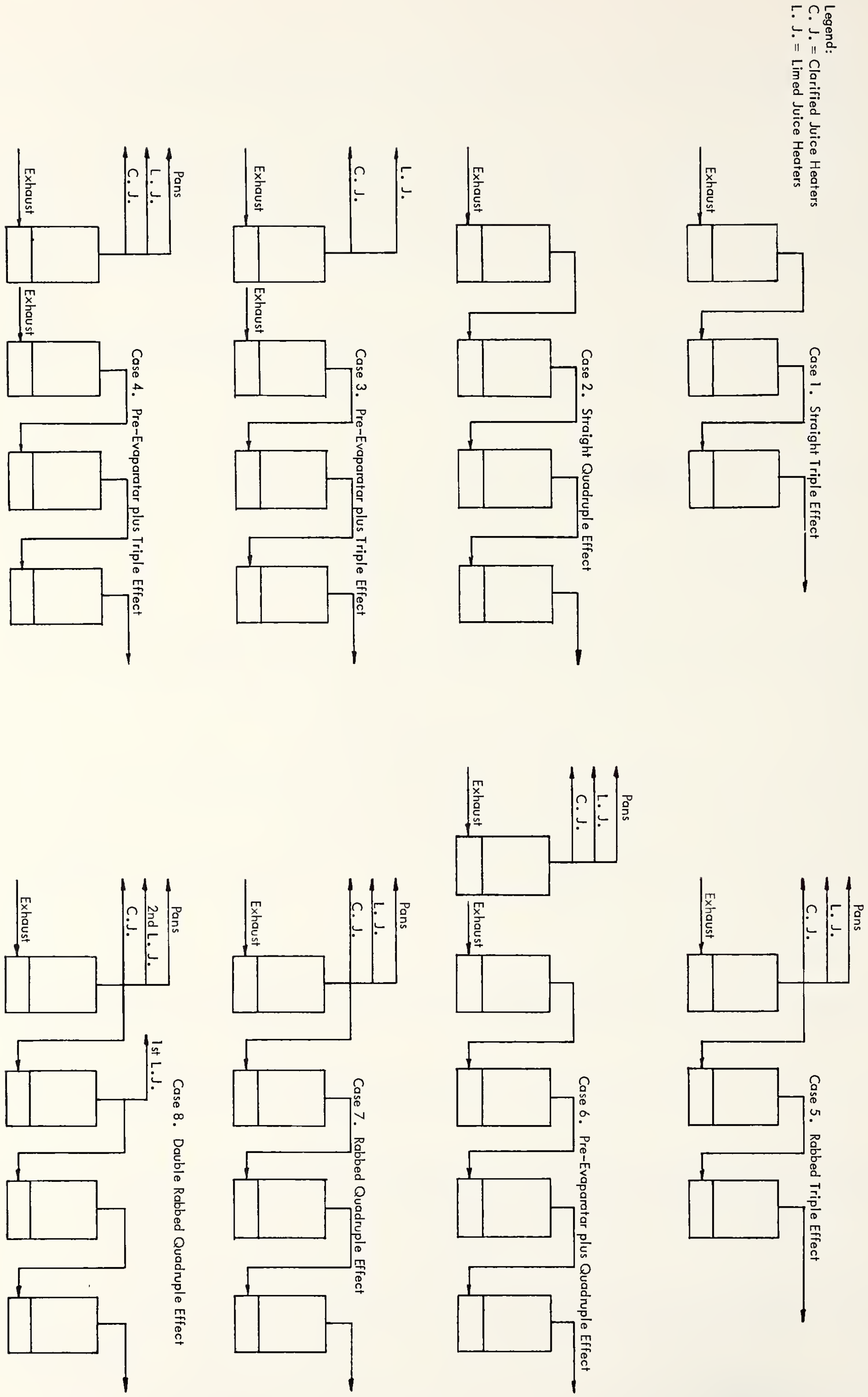
Legend:
C. J. = Clarified Juice Heaters
L. J. = Limed Juice Heaters
Case 1. Straight Triple Effect
Exhaust
Case 2. Straight Quadruple Effect
Exhaust
Case 3. Pre-Evaporator plus Triple Effect
L. J.
C. J.
Exhaust
Exhaust
Case 4. Pre-Evaporator plus Triple Effect
Pans
L. J.
C. J.
Exhaust
Exhaust
Case 5. Rabbed Triple Effect
Pans
L. J.
C. J.
Exhaust
Case 6. Pre-Evaporator plus Quadruple Effect
Pans
L. J.
C. J.
Exhaust
Exhaust
Case 7. Rabbed Quadruple Effect
Pans
L. J.
C. J.
Exhaust
Case 8. Double Rabbed Quadruple Effect
Pans
2nd L. J.
C.J.
1st L.J.
Exhaust

Fig. 8. Evaporator changes.

PAPERS FROM 1975 MEETINGS

DISEASES AS A FACTOR INFLUENCING SUGARCANE YIELDS IN LOUISIANA DURING THE LAST DECADE[1]

H. Koike
USDA, ARS, Southern Region
U.S. Sugarcane Laboratory
Houma, Louisiana

ABSTRACT

Disease is only one cause of reduced sugarcane growth and yield. Two major factors related to diseases may have contributed to declining cane yields in Louisiana during the past decade: (a) increase in mosaic disease incidence in the susceptible varieties like CP 52-68 and L 60-25 and in the moderately susceptible varieties like CP 61-37 and L 62-96; and (b) the release and cultivation of a variety like L 62-96 (or the recently released L 65-69) that is highly susceptible to injury by ratoon stunting disease (RSD). There has been no major change in the mosaic strain picture, nor is there any evidence of a new heat-resistant strain of the RSD organism. There has been no apparent change in red rot and root rot injury to varieties in the past decade, and diseases such as red stripe, pokkah boeng, and chlorotic streak are unimportant in present varieties under present cultural practices. Losses from a combination of diseases (e.g., mosaic and RSD) can be additive or synergistic, and combinations of diseases occur in commercial fields. Severity of the effects of diseases on the crop may be increased by several factors that affect growth, such as drought, freeze, cold and wet weather, and chemical injury.

Any interference in the normal processes of a plant is likely to reduce growth, and, if persistent, is almost certain to reduce yield, also. Disease can reduce growth and yield, and the severity of its effect is determined by the action and interaction of pathogen, variety of plant, environment, and cultural practices. Some factors related to diseases have changed in the past decade and may have contributed to declining cane yields in Louisiana during the past decade.

There has definitely been an increase in incidence of mosaic in mosaic-susceptible varieties like CP 52-68 and L 60-25. The variety CP 52-68 was practically free of mosaic when it was released about 15 years ago, but today, with few exceptions, no one rogues the variety due to high disease incidence. The spread of mosaic in the mosaic-susceptible variety L 60-25 released only 9 years ago has made the variety too difficult to rogue in most areas. Similarly, in the moderately resistant varieties CP 61-37, released in 1967, and L 62-96, released in 1969, the incidence of mosaic has increased so that roguing is not practicable in most areas.

There has been no major change in the mosaic strain pattern in recent years. As shown in surveys by R. L. Tippett (personal communication) and by me during the past 8 years, strain H still predominates. The highest incidence (20-30%) of strain I has been observed in the Teche area during the past 8 years; in other areas of the sugar belt, strain I has remained variable and moderate in incidence. Declining yields during the past 10 years cannot be attributed to a new strain of sugarcane mosaic.

Except for CP 52-68 and L 60-25, which are tolerant to ratoon stunting disease (RSD), the major varieties grown today are susceptible to RSD injury. Among the varieties released during the past 10 years, L 62-96 and L 65-69 have been particularly susceptible to RSD injury.

There has been no report of strains of the RSD organism. By responses of different varieties to heat cure for RSD, there is no evidence of the development of heat-resistant strains of the organism.

Red rot and root rot injury to varieties has not apparently changed in the past decade. Diseases such as red stripe, pokkah boeng, and chlorotic streak, are unimportant in varieties under present cultural practices.

Diseases directly and indirectly affect sugarcane varieties.

Direct Effects. In the mosaic-susceptible variety CP 44-101, yields are reduced progressively from plant cane to second stubble, whereas in the mosaic-tolerant variety NCo 310, yields do not decrease comparably in stubble crops (Table 1) (2).

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[1] Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

Table 1. Percentage of reduction in sugarcane tonnage due to 100% infection with mosaic.

Variety	Plant cane 1957	First stubble 1958	Second stubble 1959
CP 44-101	16.8	31.3	50.3
NCo 310	16.2	5.3	16.7

Yield is reduced as the incidence or levels of mosaic increase (Table 2). Levels of mosaic lower than 50% have not been shown to injure cane significantly. With mosaic-susceptible varieties like CP 52-68 and L 60-25, yields usually are significantly reduced when infection levels reach 50% or higher, with greater reductions at higher levels (7, 8). With varieties like NCo 310 and CP 65-357, which are more tolerant to mosaic injury, yields at the higher levels of infection are reduced much less than with the more susceptible varieties.

Table 2. Percentage of reduction in sugarcane tonnage due to different levels of mosaic.

Variety	Levels of mosaic (%)			
	25	50	75	100
		Plant cane 1965 (8)		
CP 52-68	5.8	12.0	-	33.8
L 60-25	+6.8	12.5	-	29.6
		Plant cane 1973		
CP 52-68	-	19.2	30.2	-
CP 65-357	-	7.6	13.2	-

Different strains of mosaic affect varieties differently. Our results (Table 3) show that strain I more severely affects yields than strain H; strain I affects stands and stubbling ability more severely in some varieties than does strain H (4, 9).

Table 3. Percentage of reduction in sugarcane tonnage due to strains of mosaic (Plant cane, 1969) (9)

Variety	Strains of mosaic	
	H	I
CP 48-103	22.0	60.2
CP 61-37	32.2	53.7
L 60-25	48.2	70.6

Yield reductions from ratoon stunting disease become more pronounced in stubble crops, as shown on our recent test (Table 4). These results also show that L 62-96 and L 65-69 are more susceptible to RSD injury than the RSD-tolerant variety CP 52-68.

Table 4. Percentage of reduction in sugarcane tonnage due to ratoon stunting disease.

Variety	Plant cane 1973	First stubble 1974
CP 52-68	6.9	18.4
L 62-96	12.9*	33.5**
L 65-69	28.3**	35.3**

*, **Significant respectively at the 5% and 1% level of probability.

Combinations of diseases often reduce growth and yields more than each disease separately. Research at the Louisiana Agricultural Experiment Station and at the USDA Sugarcane Laboratory in Houma have shown additive effects of mosaic and RSD on some varieties. Table 5 shows additive effects of the two diseases on CP 61-37; similar results were obtained for L 62-96.

Table 5. Percentage of reduction in sugarcane yields due to mosaic and ratoon stunting disease (RSD), singly and in combination*.

	Variety			
	CP 52-68		CP 61-37	
Treatment	TC/A	lb S/A	TC/A	lb S/A
Mosaic	33.3	29.5	33.0	27.4
RSD	2.8	1.9	24.8	18.4
Mosaic + RSD	38.9	33.2	55.2	50.9

*Means of plant cane, 1972, and first stubble, 1973.

Koike and Yang (5) reported additive and synergistic effects of mosaic and Pythium root rot on growth and weights of different sugarcane varieties.

Two or more diseases in one plant are common in the field, and no doubt additive and synergistic effects of diseases occur in commercial sugarcane.

Indirect Effects. Stubble cane, particularly of CP 52-68 and L 60-25, has failed in recent years in several locations. Circumstantial evidence indicates that heavy mosaic infection might have made the stubble cane more susceptible to freezes. Test results with mosaic-diseased and healthy cane exposed to artificial freezes show that mosaic-diseased cane is more susceptible to freezes than healthy cane (J. E. Irvine, personal communication). Irvine observed that in the field, also, varieties with mosaic are more susceptible to freeze damage than mosaic-free cane.

Yang and Koike (10) observed moderate, additive effects of moisture stress and of infection with the black rot fungus *Ceratocystis adiposa* on stubbling ability of CP 61-37 and L 60-25.

Evidences of combined effects of preemergence herbicides and red rot disease have been observed in summer-planted L 62-96. The combined effects were especially noticeable in fields or parts of fields where the herbicides had inhibited the normal development of shoot roots. The red rot disease was noted both in the seed cane with shoots and shoot roots growing normally and in seed cane with shoot roots distorted and roots and shoots inhibited in growth. In the latter, the disease had completely rotted the stalks, whereas in the former, disease spread was limited.

Moreover, RSD is more severe in its effects when cane plants are exposed to drought stress. Droughts that crops were exposed to during the last 3 years undoubtedly magnified the effects of RSD in diseased cane.

Also, the wet winter of 1972-1973 no doubt contributed to a higher incidence of seedpiece rot. Abbott (1) mentioned that "low temperatures and excessive rainfall, which are in themselves unfavorable for good cane growth, are in turn favorable for the development of red rot and root rot, while warm, dry conditions favoring cane, lessen development of these diseases." McDonald (as quoted in Abbott (1)) concluded from his study of weather in relation to sugar production in Louisiana, "Wet, cold conditions at the beginning of growth mark low production years, and warm, dry weather in the same growth period favors high yields."

At times, disease can be the main cause of yield reductions, but at other times, it may be considered secondary to other effects--chemical, physiological, or environmental. Growth and yield may also be reduced in the absence of diseases.

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ENHANCEMENT OF FLOWERING IN CLEWISTON VARIETIES BY CONTROLLED PHOTOPERIODS[1]

D. G. Holder
United States Sugar Corporation
Clewiston, Florida 33440

ABSTRACT

Controlled photoperiods have been used to enhance flowering in Clewiston (Cl) varieties for the breeding program at United States Sugar Corporation for 3 seasons. Varieties subjected to controlled photoperiods were maintained in can cultures. During photoperiod treatments, plants received natural sunlight for 9 hr each day, then they were placed in a light-proof chamber where a mixture of fluorescent and incandescent light bulbs provided a short period of light in the evening and in the morning. Thus, the photoperiod was continuous without interruption. Beginning the controlled photoperiods in July at 12 hr 50 min and shortening the photoperiod about a minute per day to 12 hr 15 min or to less than 12 hr 15 min produced good flowering response in many Cl varieties. Most flowering was from late November to late December under these systems.

INTRODUCTION

In Florida some of the best varieties for commercial production flower very late, very little, or not at all under natural field conditions. While minimal to non-flowering is desirable for commercial production, it poses a problem for breeders. In field plots many varieties with desirable characteristics can be used in breeding only sporadically or never.

Manipulation of the photoperiod is a tool used by breeders to induce flowering in sugarcane to bring a wider range of clones into crossing programs and to synchronize those clones which normally flower under natural conditions. In 1938 Sartoris (7) reported that a clone of Saccharum spontaneum flowered with a 13 hr photoperiod. Chilton and Paliatseas (1) produced flowers in several clones when they started the photoperiod at 12 hr 44 min and reduced the light period by 1 minute per day. Using a continuous 12 hr 25 min photoperiod, Coleman (2) obtained flowering in two clones. Paliatseas (5) found that most varieties he tested were initiated to flower in an effective range of 12 hr to 12 hr 30 min. It has further been shown (4, 6) that a photoperiod shorter than 12.5 hr is desirable for the development and emergence of the initiated inflorescence. James (3) has produced flowers in many clones by starting the photoperiod at 12 hr 50 min and gradually reducing the light period. This cycle and variations of it have contributed greatly to the volume of crosses made in the USDA program at Canal Point, Florida (4).

At United States Sugar Corporation controlled photoperiod has been used for 3 years to produce flowers in a number of clones to broaden the scope of the breeding program. This paper reports the response of Clewiston (Cl) varieties to the photoperiod treatments imposed in 1972, 1973, and 1974.

METHODS AND MATERIALS

Each year varieties which were subjected to controlled photoperiods were handled very nearly the same. Clones were planted as single-eye-seedpieces in muck soil in January. The young plants were transplanted to 10 gal cans in March with 2 plants in each can. The soil was a 1:1 mixture of sand and muck, with fertilizer added to keep a high nutritional status through June. After June, plants were fertilized only if deficiency symptoms were noticed. Plants were watered regularly.

The cans of plant material were on carts for manipulation during treatments. During the period of photoperiod control the plants were exposed to natural sunlight and conditions from 8:00 am to 5:00 pm. All times are Eastern Daylight Time. The plants were in light-proof chambers from 5:00 pm to 8:00 am where the photoperiod could be controlled by artificial lighting. The lights were on in the chambers at 5:00 pm. An automatic timer was used to turn the lights off in the evening and on in the morning so there were periods of artificial light both before and after the natural sunlight. The lights were mounted 20 ft above the base of the cane. A string of 6 200-watt incandescent bulbs were spaced about 3 ft apart and 4 80-watt fluorescent bulbs were in the center of each 10 ft x 20 ft chamber. During July, August, and September, night temperatures in the chambers were 80-83 F. In October, November, and December the night temperatures were 75-80 F. When treatments were terminated plants were exposed to natural daylengths.

Two treatments were applied each season with the idea of spreading the flowering period of individual varieties. The flowering date was recorded as the first day a flower could be used in a cross.

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[1] This paper was presented at the 1975 meeting of the Florida Division of the ASSCT.

During the 1972 season treatments 1 and 2 began on July 19 with photoperiods of 12 hr 50 min. The photoperiod in treatment 1 (5:15 am to 6:05 pm) was reduced gradually for 37 days to 12 hr 15 min (5:30 am to 5:45 pm). The photoperiod was then held constant for 102 days and terminated on December 5. The photoperiod in treatment 2 (5:19 am to 6:09 pm) was gradually reduced to 12 hr 31 min (5:29 am to 6:00 pm) in 24 days. The photoperiod was then held constant for 115 days until December 5.

During the 1973 season treatments 3 and 4 were started on July 19. Treatment 3 began with a 12 hr 45 min photoperiod (6:47 am to 7:32 pm) which was reduced slowly for 30 days to a photoperiod of 12 hr 15 min (6:56 am to 7:11 pm). The 12 hr 15 min photoperiod was maintained for 90 days and stopped on November 14. Treatment 4 began with a 12 hr 47 min photoperiod (6:46 am to 7:33 pm) which was gradually shortened for 60 days to 11 hr 50 min (7:16 am to 7:06 pm). The 11 hr 50 min photoperiod was maintained 40 days and terminated on October 25.

Treatments 5 and 6 were conducted during the 1974 season. The treatments were started on August 1, which was about 2 weeks later than in the previous years. Treatment 5 began as a 12 hr 45 min photoperiod (6:05 am to 6:50 ppm), which was shortened continuously for 122 days and terminated on December 1 at 10 hr 47 min (7:10 am to 5:57 pm). Treatment 6 began with a 12 hr 48 min photoperiod (6:04 am to 6:52 pm), which was shortened gradually over a period of 22 days to 12 hr 29 min. Then, the photoperiod was held constant for 14 days. The photoperiod was again shortened gradually over a period of 78 days to 11 hr 6 min (7:03 am to 6:09 pm). The treatment was terminated on November 22.

RESULTS AND DISCUSSION

The response to treatments 1 and 2 was encouraging (Table 1). Three varieties produced flowers under both treatments. There was generally a better response to treatment 1, which ran a long duration at a 12 hr 15 min photoperiod, than to treatment 2, which ran a long duration at a 12 hr 31 min photoperiod. All varieties bolted in both treatments. In those varieties which flowered under both systems the flowers emerged earlier under treatment 1. This indicates that a shorter photoperiod than 12 hr 31 min is helpful for the development and emergence of the initiated inflorescence in Cl varieties. A similar response occurs in other type varieties (4, 6). Except for Cl 59-1332, most flowering was in late December and January. It is more desirable to have the bulk of flowering in December to coincide with naturally flowering varieties. Of the clones included in the test, only Cl 59-1332 flowered in field plots. The field flowers were a month later than those from the treatments.

Table 1. Flowering response of 8 varieties subjected to controlled photoperiods during 1972.

	No. stalks treated		Percent emergence		Days to flowering[1/]			
					Range		Mean	
Clone	Treat. 1	Treat. 2	Treat. 1	Treat. 2	Treat. 1	Treat. 2	Treat. 1	Treat. 2
F 36-819	13	12	23	0	180-188	-	182	-
Cl 47-83	20	18	70	0	163-188	-	172	-
Cl 54-312	20	21	0	0	-	-	-	-
Cl 54-336	20	16	20	0	188-188	-	188	-
Cl 54-378	12	16	58	88	145-173	149-184	154	174
Cl 54-405	21	21	0	0	-	-	-	-
Cl 58-37	15	15	0	0	-	-	-	-
Cl 59-1332	9	9	78	89	117-119	134-145	118	136
Cl 61-205	17	21	12	14	149-177	149-177	163	167

[1/] Days from beginning of treatment to flowering.

The response to treatments 3 and 4 was excellent (Table 2). There was nearly 100% flowering under both photoperiod cycles. Most flowers were utilized during the period November 10 to December 20, which coincided with the peak of natural flowering. The flowers produced from treatment 3, where the post-inductive photoperiod was held at 12 hr 15 min, were generally later than those produced in treatment 4, where the post-inductive photoperiod was decreased to 11 hr 50 min. In treatment 3, four varieties were 1 to 2 weeks later and four varieties were 4 to 5 weeks later than in treatment 4. Only Cl 47-83, Cl 59-1332, and Cl 54-378 flowered under natural conditions, but all natural flowering was too late to effectively be used in the crossing program.

Table 2. Flowering response of 8 varieties subjected to controlled photoperiods during 1973.

Clone	No. stalks treated		Percent emergence		Days to flowering[1]			
					Range		Mean	
	Treat. 3	Treat. 4	Treat. 3	Treat. 4	Treat. 3	Treat. 4	Treat. 3	Treat. 4
F 36-819	12	11	100	100	145-165	126-135	154	130
Cl 47-83	15	14	100	100	164-172	128-137	168	134
Cl 54-378	21	20	100	100	149-159	116-124	153	119
Cl 54-405	12	12	100	100	164-176	135-153	170	144
Cl 59-1332	14	18	100	100	128-143	114-131	131	119
Cl 61-205	10	12	100	67	135-159	128-145	144	135
Cl 61-355	12	16	58	100	142-159	124-146	151	133
Cl 65-260	10	11	100	100	145-166	121-137	158	128

1/Days from beginning of treatment to flowering.

Treatments 5 and 6 were successful in producing a large number of flowers (Table 3). There was only a difference of a few days in the range of flowering for individual varieties entered in both treatments. The period of most flowering was December 1 to December 20, which was satisfactory for making crosses with naturally flowering nursery materials. In those clones which had less than 100% flowering there were many initiated stalks in which the inflorescence aborted before emergence. Of the clones treated, only Cl 54-336 and Cl 54-378 showed signs of bolting under natural conditions near the end of the crossing season.

Table 3. Flowering response of 10 varieties subjected to controlled photoperiods during 1974.

Clone	No. stalks treated		Percent emergence		Days to flowering[1]			
					Range		Mean	
	Treat. 5	Treat. 6	Treat. 5	Treat. 6	Treat. 5	Treat. 6	Treat. 5	Treat. 6
F 36-819	13	-	69	-	128-153	-	137	-
Cl 47-83	14	13	100	100	135-142	132-139	139	137
Cl 49-200	9	8	22	25	128-135	135-135	132	135
Cl 54-336	15	-	100	-	142-149	-	146	-
Cl 54-378	17	13	100	100	121-132	123-132	126	126
Cl 58-37	14	12	57	50	132-139	132-142	136	137
Cl 61-205	17	41	76	83	128-142	124-142	134	133
Cl 61-355	16	13	56	92	132-135	120-135	133	129
Cl 65-260	14	13	40	15	139-160	139-139	151	139
Cl 66-577	7	7	43	71	132-132	132-145	132	136

1/Days from beginning of treatment to flowering.

Nearly 100% of the flowers produced by controlled photoperiods have been used in crosses. Such clones as Cl 47-83, Cl 49-200, Cl 54-378, Cl 58-37, Cl 61-205, and Cl 61-355 have been primarily used as male parents. Cl 59-1332 is normally used as a female parent under natural flowering conditions. Flowers of Cl 59-1332 from treatment 4 in 1973 were functionally female; however, those from treatment 3 emerged later and were good pollen producers. Other clones flowering under controlled photoperiods were used as female parents.

Beginning the controlled photoperiod in July at 12 hr 50 min and gradually shortening the photoperiod about a minute per day to 12 hr 15 min or less produced satisfactory flowering in most Cl varieties. Most flowering was from late November to late December under these systems. The degree of flowering and time of emergence varied with varieties.

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IRRIGATION SCHEDULING FOR SUGARCANE IN THE LOWER RIO GRANDE VALLEY OF TEXAS

Francisco Salinas and L. N. Namken
Agricultural Research Service, USDA
Weslaco, Texas

ABSTRACT

The Jensen-Haise irrigation scheduling method is a practical way of estimating soil water depletion by evapotranspiration to schedule sugarcane irrigations in South Texas. Sugarcane crop coefficients for estimating soil water depletion using climatic, soil, and crop parameters were determined. Daily soil water depletion was estimated for subsequent sugarcane crops by utilizing the crop coefficients, solar radiation, and mean air temperature, and irrigations were scheduled by a soil water accounting procedure. Over a 2-year period, the irrigation scheduling procedure estimated irrigations within 1 to 2 days of that indicated by the measured soil water status. The procedure also estimates the amount of water required to refill the root zone.

INTRODUCTION

Limited water resources in many parts of the country require efficient water utilization by all disciplines. Agriculture in arid and semiarid regions must be particularly efficient, since enormous amounts of irrigation water are used to produce crops. Whether water use is efficient depends upon growers knowing when to irrigate and how much water to apply. Moreover, they must have some knowledge of the soil water status at any given time, to assist in making crop management decisions (17, 1, 12). Many growers have recognized the need for increased irrigation efficiencies. Proper irrigation scheduling--timing of irrigations and amount of water applied--can be very effective means of increasing water use efficiencies (2, 3, 13).

During the past 30 years, many scientific man years have been expended throughout the world developing various approaches to provide the grower with a practical method to schedule crop irrigations. Several instruments are commercially available for determining the soil water status, like soil moisture blocks, tensiometers, thermal conductivity units, and neutron metering devices (7, 2, 3, 6). These instruments are important research tools; however, they are not satisfactory, practical, or economical for field use by growers.

Many methods for estimating evapotranspiration (ET) for various crops in broad climatic regions have been developed. Penman (15) and Thornthwaite (16) developed different procedures to estimate ET using the energy balance approach. These procedures have limitations for widescale use by growers because they require elaborate instrumentation to collect the needed meteorological data.

Jensen and Haise (8, 9) estimated ET effectively using solar radiation (Rs) and mean air temperature (Tm) as the main parameters. Their procedure is simple and provides desirable, short-term, average ET estimates; however, the method does require a crop coefficient curve that expresses the ratio of ET to potential ET (ET/ETp) as a function of crop growth stage.

Sugarcane is a tropical crop which requires an adequate soil water supply to achieve optimum growth (14, 4, 5). Sugarcane growth is frequently restricted by a limited seasonal rainfall in the Lower Rio Grande Valley of Texas. Therefore, effective irrigation management practices are essential.

Our purpose in this paper is to develop and test crop coefficients for estimating ET of sugarcane in this climatic region (Lower Rio Grande Valley) and to describe a grower-oriented irrigation scheduling technique (Jensen-Haise Method) which can be used by growers, irrigation districts, or private service companies.

THEORY

Irrigation scheduling using meteorological data (energy budget approach) relies on dependable daily estimates of potential ET (ETp). Potential ET is defined as the ET of a crop with complete ground cover (aerodynamically rough surface) having adequate moisture. ETp is governed by climatic factors, like solar radiation (RS), temperature, humidity, dew point, and wind. In South Texas, it has not been necessary to consider the last three factors since the continuous prevailing winds from the Gulf of Mexico carry in moisture which results in high relative humidities. Therefore, ETp is computed as follows (10, 11):

$$ETp = C_T\ (Tm - Tx)\ Rs$$

where C_T = an air temperature constant derived from the long-term mean maximum and minimum air temperature for the warmest month at a given location. (0.0112 for South Texas) $C_T = 1.0/(C_1 + C_2 C_H)$

where $C_1 = \frac{68 - 3.6\ (\text{elevation})}{1000}$

$C_2 = 13$

$C_H = 37.5/(Psx - Psn)$

where Psx = saturated vapor pressure at mean maximum daily temperature

Psn = saturated vapor pressure at mean minimum daily temperature

Tm = mean daily air temperature;

Tx = a location constant which is the linear equation intercept on the temperature axis, 20.0 for South Texas; (Tx = 27.5 - 0.33 (Psx - Psn) - E/1000)

Rs = daily solar radiation expressed in equivalent depth of water evaporated.

To compensate for the stage of crop development and the difference among crops the Jensen-Haise Method requires a crop coefficient. This dimensionless coefficient, unique to each type of crop (citrus, sugarcane, cotton, etc.), adjusts the ETp to the expected ET for the particular crop:

$$ET = KcETp$$

where Kc = a dimensionless unique crop coefficient which is also influenced by soil surface wetness and the diminishing available soil water. This Kc is estimated as follows:

$$Kc = KcoKa + Ks$$

where Kco = the mean crop coefficient developed experimentally from crops with adequate soil water and normal irrigation;

Ka = a relative crop coefficient as influenced by available soil water. It is proportional to the logarithm of the percentage of remaining available soil water (AW):

$$Ka = \ln\ (AW + 1)/\ln\ (101);$$

Ks = a coefficient reflecting soil surface wetness due to irrigation or rainfall. Values for the first, second, and third day after rain or irrigation are (0.9 - Kco) 0.8; (0.9 - Kco) 0.5; and (0.9 - Kco) 0.3, respectively.

The total value for KccKa + Ks will not exceed 1.0 for most crops (11).

EXPERIMENTAL PROCEDURES

This experiment was designed to obtain the ET data necessary for developing a crop coefficient curve for sugarcane and was conducted at Weslaco, Texas, on a Hidalgo sandy clay loam soil. Sugarcane variety NCo 310 was planted in December 1971 using a complete factorial with three row spacings--122, 152, and 182 cm--and three irrigation regimes--40, 60, and 80% allowable depletion--arranged in a randomized complete block design in triplicate. Plots were six rows wide by 15.2 m long. Each plot contained an access tube to measure soil water with a neutron probe at 30-, 60-, 91-, 122-, and 152-cm soil depths each week and before and after irrigations. Irrigation treatments were based on the average water content in the top 61 cm of soil profile; however, irrigation applications were made to replenish the entire 1.5-m soil profile to field capacity. Irrigation water was measured with a Hersey-Sparling meter.

Plant canopy height was measured weekly to relate crop coefficients to the stage of crop growth.

The ET was determined from two complete growing seasons in 1972 and 1973. Periods not used were those between the last soil water measurement before irrigations and the first measurement after irrigations, as well as those intervals when there would have been considerable drainage, as when heavy rains followed an irrigation.

Solar radiation data were obtained from an Eppley pyranometer located at the USDA Research Farm's weather station adjacent to the study area. Temperature data were obtained from official U. S. Weather Bureau maximum and minimum thermometers at this station.

The length of the growing season was from planting to harvest for the plant crop and from initiation of regreening to harvest for ratoon crops, unless there was a late frost in the spring, then the growing season started at the frost date. The period before effective cover (Fig. 3) was organized on a percent-of-season basis to compensate for differences in the time growth starts in late winter or early spring. Longevity of period was estimated as number of days between starting date and effective cover.

RESULTS AND DISCUSSION

Development of Crop Coefficients

The ET:ETp ratios for sugarcane variety NCo 310, grown on two-row spacings, were calculated from measured ET values obtained during drying cycles in 1972. These ratios versus canopy height (Fig. 1) establish the canopy height at which ET is maximum. The ratios increased rapidly from less than 0.1 at the starting date to nearly 1.0 when the canopy heights reached 120 cm. Thereafter, the ratios leveled off and remained slightly below 1.0 for the rest of the growing season. This shows that ET is maximum when canopy height is approximately 120 cm. The row spacings tested did not seem to affect time of maximum ET.

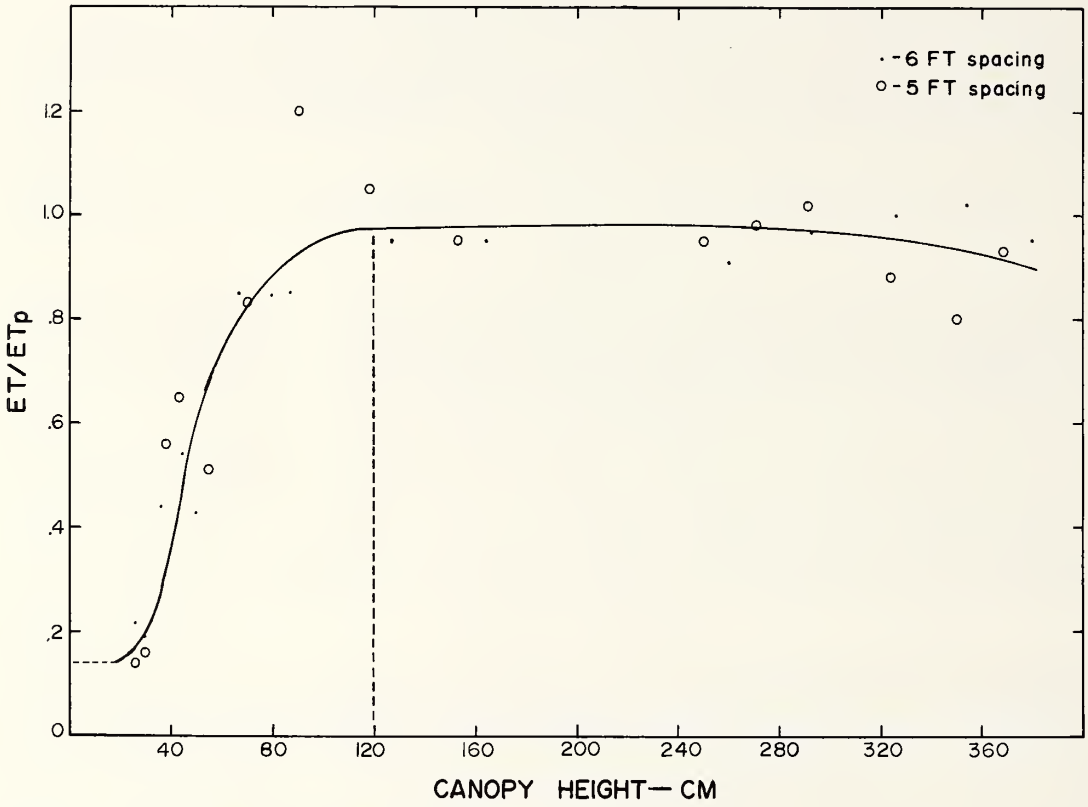

Figure 1. ET/ETp ratio vs. canopy height.

Canopy height was also plotted as a function of time to determine when canopy height reached 120 cm (Fig. 2). Canopy height reached 120 cm on about May 15 for the 1972 and 1973 growing seasons. Figure 2 represents cane growth data for both years. Using this information, a crop factor curve (Kco) for sugarcane NCo 310 in the Lower Rio Grande Valley was determined (Fig. 3). These crop coefficients enable the prediction of the soil water depletion and the scheduling of irrigation from weather data (incident solar radiation and mean daily temperature).

Testing of Crop Coefficients

The soil water depletion schedule is usually started after a heavy rain or an irrigation when the soil water is near field capacity. ET estimates are determined daily. By subtracting ET from the available water supply and by adding precipitation and irrigation to the supply, a running balance is maintained so that the amount of available water in the soil profile at any time is known. When the available water in the soil is depleted to a predetermined amount, irrigations are initiated. This procedure also provides an estimate of how much water should be applied to replenish the soil with water.

The crop coefficients reported here were used for irrigation scheduling of three irrigation regimes during the 1973 and 1974 sugarcane crops at our USDA Research Farm and at 10 other sugarcane fields in cooperation with growers. The technique satisfactorily estimates crop water use.

Table 1 shows the irrigation dates as determined for the 60% allowable depletion treatment with the 4-, 5-, and 6-ft row spacings. The estimate dates vary from 1 to 2 days as compared with the measured soil moisture status. Figure 4 shows two moisture depletion schedules with reasonably close agreement between measured and estimated soil moisture. This degree of accuracy is well within the growers' practical needs.

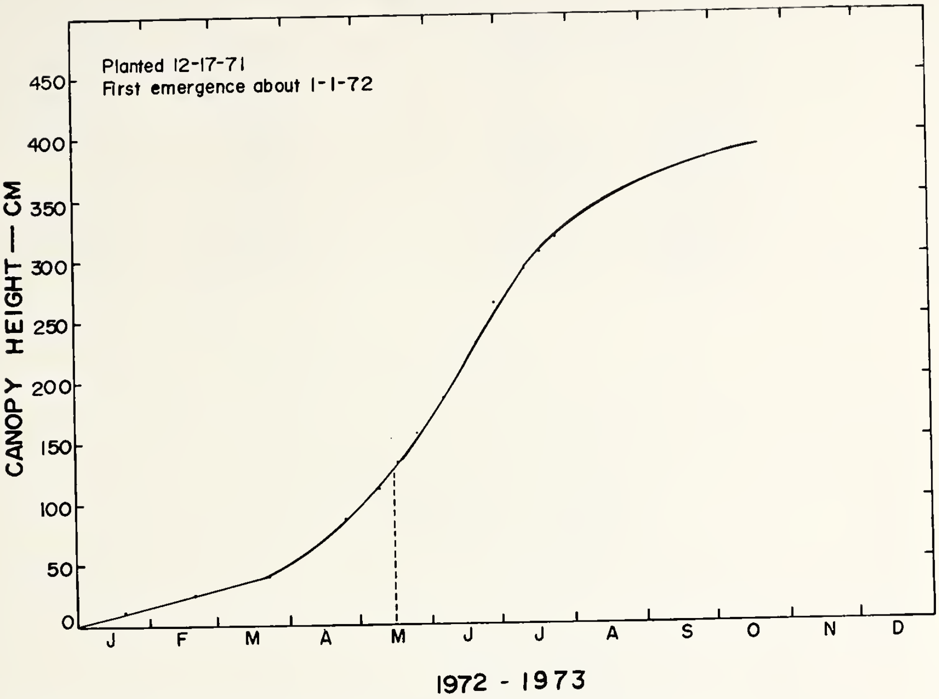

Figure 2. Canopy height vs. time for two growing seasons.

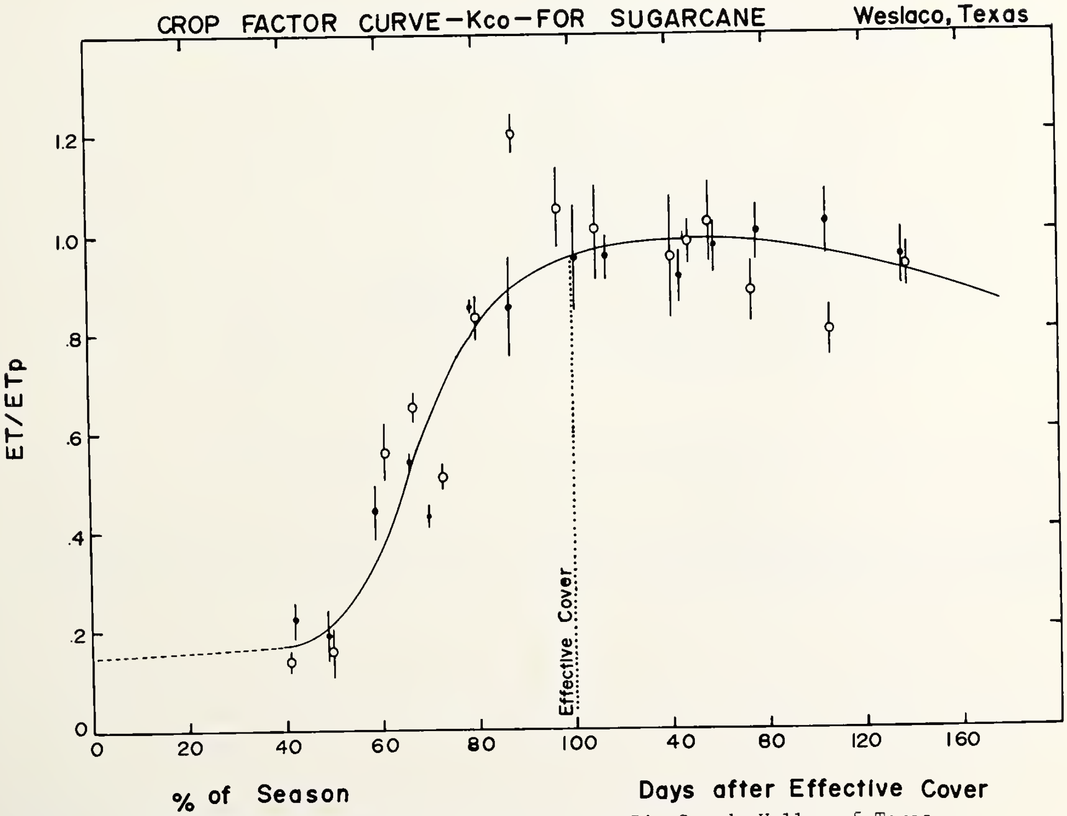

Figure 3. Sugarcane crop coefficient curve for Lower Rio Grande Valley of Texas.

Table 1. Irrigation dates for 60% water depletion estimated by evapotranspiration methods and measured by neutron probe for three different sugarcane row spacings during 1974.

4-ft row spacing		5-ft row spacing		6-ft row spacing	
Estimated	Measured	Estimated	Measured	Estimated	Measured
March 3	March 2	March 10	--	February 20	February 21
April 17	April 17	April 26	April 24	April 29	--
May 17	May 20	May 21	May 20	May 21	May 20
June 7	June 8	June 5	June 6	June 6	June 6
June 27	--	June 27	June 27	June 27	June 28
July 20	July 20	July 20	July 18	July 19	July 20
August 6	August 7	August 5	August 6	August 5	August 5
August 21	August 21	August 21	August 21	August 21	August 21

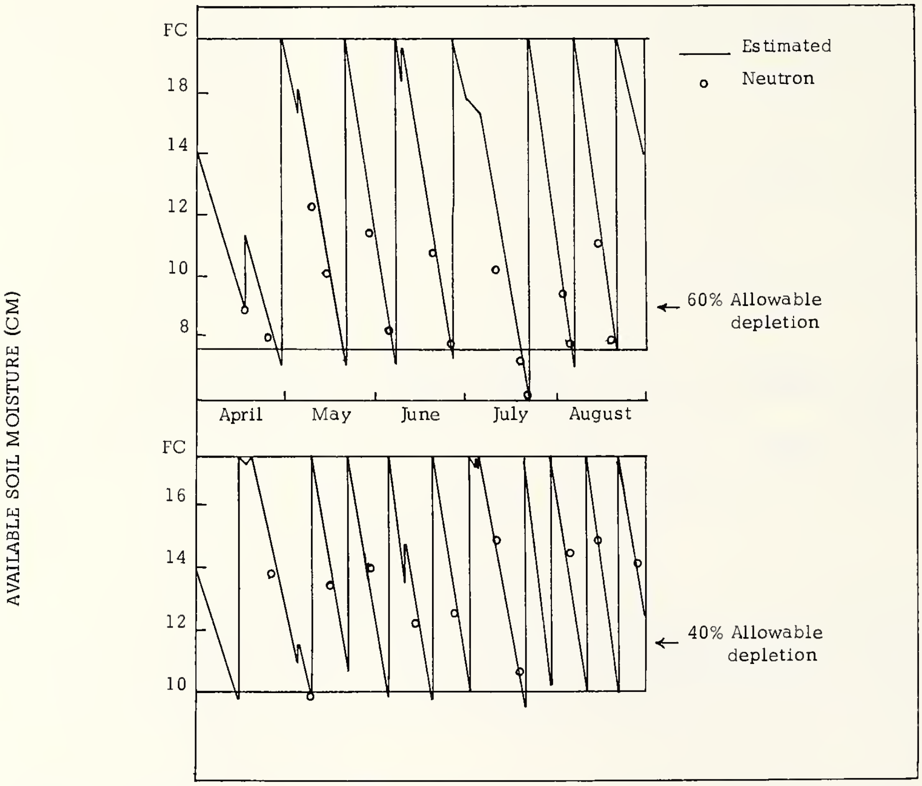

Figure 4. Estimated and measured available soil moisture for two irrigation regimes.

The Jensen-Haise method of scheduling irrigations in the Lower Rio Grande Valley is a very useful water management tool for increasing water-use efficiency. The procedure is simple, and growers can easily develop their own scheduling programs.

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PINEAPPLE DISEASE IN SOME FIELDS ASSOCIATED WITH POOR GERMINATION OF SEED CANE IN LOUISIANA[1]

Shaw-ming Yang
U.S. Sugarcane Field Laboratory, Southern Region, ARS, USDA
Houma, Louisiana 70361

ABSTRACT

Poor stands occurred in commercial sugarcane fields in Louisiana in 1974 and 1975. Field observations were followed by sampling of ungerminated seed pieces of 3 cultivars (CP 52-68, CP 65-357, and L 62-96). Samples were taken from sandy loam and heavy clay fields planted with hot-air-treated and untreated seed pieces. Symptoms suggested the presence of pineapple disease, red rot, and stem rot. Isolations made from ungerminated seed pieces yielded fungi belonging to 11 species and 7 genera. Of these isolates, only those causing pineapple disease (Ceratocystis paradoxa), red rot (Colletotrichum falcatum), and stem rot (Fusarium moniliforme) affected germination. C. paradoxa was isolated from 86% of 169 ungerminated seed-piece samples from sandy loam and from 38% of 112 samples from heavy clay. The fungus was also obtained from 93% and 35% of soil samples of sandy loam and heavy clay, respectively. C. falcatum was isolated from 2% of 169 ungerminated seed-piece samples from sandy loam, and from 13% of 112 samples of seed pieces from heavy clay. This fungus was not obtained from soil samples. The results suggest that pineapple disease contributed to poor stands, particularly in sandy loam.

INTRODUCTION

Poor stands of 3 sugarcane cultivars, CP 52-68, CP 65-357, and L 62-96, were observed in 1974 and 1975 in some fields of Valhi, Inc., in Houma and Thibodaux. Both hot-air-treated and untreated seed pieces were involved. Many ungerminated seed pieces showed a black discoloration and disintegration of the central core; others exhibited a red to reddish brown internal discoloration. The internal discoloration of the ungerminated seed pieces suggested that fungal pathogens were involved.

Fungal pathogens associated with seed-piece rot are well documented in the literature (1, 2, 6, 8, 10). In Louisiana the red rot (Colletotrichum falcatum Went, the imperfect stage of Glomerella tucumanensis (Spec.) v. Arx et E. Muell) is considered the most important seed-piece disease (1, 2, 6). Pineapple disease (Ceratocystis paradoxa (Dade) C. Moreau) occurred occasionally in seed pieces planted in poorly drained soils in winter (6). The other seed-piece rots, such as Fusarium (6) and Phytophthora (10) rots, rarely occurred.

The black discoloration and disintegration of the central core in most of the ungerminated seed pieces indicated the involvement of C. paradoxa rather than C. falcatum in the poor stands of the three cultivars. Studies were, therefore, initiated to determine the fungi associated with the poor germination.

MATERIALS AND METHODS

Ungerminated seed pieces of 3 sugarcane cultivars, CP 52-68, CP 65-357, and L 62-96, were collected from fields showing poor stands. Date of planting, soil type, whether hot-air-treated or untreated seed pieces, total number of seed pieces collected from each location, and date of collection are shown in Table 1. Untreated seed pieces of CP 52-68 and L 62-96 planted in sandy loam soil were not available.

Isolation of fungi from ungerminated seed pieces. Seed pieces were washed in tap water and in 0.1% $HgCl_2$ solution, then split aseptically with a knife. Four pieces of tissues (0.5 x 1.0 cm) were removed aseptically from each internode and immersed in 0.1% $HgCl_2$ solution for 2 min and rinsed twice in sterile water for at least 5 min. The tissue pieces were incubated in petri dishes at 25 or 30 C for 2 to 7 days either on potato dextrose agar (PDA) amended with 200 ppm streptomycin or on acidified oatmeal agar (OMA). Pure cultures of isolated fungi were maintained on PDA or OMA in test tubes for identification and for pathogenicity tests.

Fungi recovered from soil. Two sandy loam soil samples and two heavy clay soil samples were collected from fields with poor stands. Pathogenic fungi were isolated from sugarcane stalk tissues which had been incubated with the soil samples. Twenty pieces of freshly cut stalk tissues without rind (1-2 x 0.5-0.8 cm) of CP 65-357, added to a sieved soil sample (2 mm mesh) in a polyethylene interlocking seal bag (25 x 25 cm), were incubated at 25 C for 1 to 2 weeks. The stalk tissues were then removed from the bag, washed in running tap water, rinsed in sterile distilled water 3 times, and placed on PDA amended with 200 ppm streptomycin or on acidified OMA in petri dishes. The plates were incubated at 25 or 30 C for 2 to 7 days. Fungi grown from the tissues were transferred to PDA or OMA in test tubes for identification and pathogenicity studies.

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[1] Research at this location is done in cooperation with the Louisiana Agricultural Experiment Station.

Ten one-node seed pieces of CP 65-357 were also planted in the sandy loam soil and heavy clay soil in pots. The planted seed pieces were kept on a greenhouse bench for 6 weeks. Numbers of ungerminated seed pieces were recorded. Fungi were isolated from the ungerminated seed pieces by the method described above.

Pathogenicity tests. Either spore suspensions or pieces of mycelium on agar of a selected isolate were used to inoculate 3 to 5 stalks of each cultivar by the puncture method (2). Stalks inoculated with sterile water or sterile agar were used as controls. The inoculated stalks were incubated at 20 to 22 C for 4 weeks before the discoloration of internal tissues was recorded. The fungi were reisolated from the inoculated stalks.

RESULTS

Isolation of fungi from ungerminated seed pieces. Eleven species belonging to 7 genera of fungi were isolated. The relative frequency of *C. paradoxa*, *C. falcatum* and *Fusarium moniliforme* (*Fusarium* seed-cane rot pathogen) and other *Fusarium* species isolated from the ungerminated seed pieces is shown in Table 1. Among seed-piece samples from sandy loam soil, *C. paradoxa* was isolated from 146 seed pieces and occurred most frequently. In decreasing order of frequency, other fungi isolated were *Trichoderma* spp. (including *T. harzianum* Rifai aggr., *T. koningii* Oud. aggr., *T. pseudokoningii* Rifai aggr., and *T. viride* Pers. ex Gray aggr.), *Fusarium* spp. (including *F. moniliforme* and *F. solani* (Mart.) Appel & Wr. 24 samples), *Penicillium* spp. (21 samples), *Aspergillus niger* Van Tieghem (11 samples), *C. falcatum* (3 samples), and *Rhizoctonia solani* Kühn (1 sample). Among the seed-piece samples from heavy clay soils, *Trichoderma* spp. (55 samples) was isolated most frequently, followed in decreasing order by *C. paradoxa* (42 samples), *A. niger* (32 samples), *Penicillium* spp. (18 samples), *C. falcatum* (16 samples), *Fusarium* spp. (14 samples), and *R. solani* (2 samples).

Table 1. Sugarcane cultivars, with or without heat treatment of seed canes, date of planting, soil types, number of ungerminated seed pieces collected, date of collection and frequency of 3 seed-piece pathogens isolated from the ungerminated seed pieces.

Cultivars	With or without hot-air treatment1/	Date planted	Soil type	No. ungerminated seed pieces collected	Date samples collected	Frequency of pathogens isolated2/		
						Ceratocystis paradoxa	*Colletotrichum falcatum*	*Fusarium moniliforme* and other *Fusarium* species
L 62-96	+	8/20/73	Loam	33	3/19/74	.62	0	.21
L 62-96	+	8/20/73	Clay	27	4/ 3/74	.33	.04	.11
L 62-96	-	8/20/73	Clay	17	3/19/74	.41	.06	.29
CP 52-68	+	8/19/73	Loam	45	4/ 3/74	.89	.02	.11
CP 52-68	+	8/19/73	Clay	35	4/ 3/74	.43	.03	.27
CP 52-68	-	9/22/74	Clay	33	1/21/75	.33	.39	.06
CP 65-357	+	9/20/73	Loam	28	3/19/74	.86	.05	.13
CP 65-357	+	8/21/74	Loam	43	11/25/74	1.00	0	.17
CP 65-357	-	8/21/74	Loam	20	11/25/74	.95	.05	.14

1/+ indicates seed pieces had been treated at 58 C inlet temperature for 8 hr before planting;
- indicates no heat treatment.

2/Frequency of fungal isolates was expressed as the number of internodes from which isolates were obtained divided by the total number of internodes of one cultivar from one location.

The red rot pathogen was isolated rarely from the ungerminated, hot-air-treated seed pieces of the 3 cultivars and infrequently from ungerminated, untreated seed pieces of CP 65-357 and L 62-96. The pathogen was observed in almost half of the ungerminated, untreated seed pieces of CP 52-68 collected from heavy clay soil. *Phytophthora* was not isolated from ungerminated seed pieces.

Fungi recovered from soil. Seven species in 3 genera of fungi were recovered from soils. The isolated fungi were *C. paradoxa*, *F. moniliforme*, *F. solani*, *T. harzianum*, *T. koningii*, *T. pseudokoningii*, and *T. viride*. *C. paradoxa* was detected in 93% and 35% of tissues buried, respectively, in sandy loam and heavy clay soils. *Fusarium* spp. were recovered from 28% and 43% of tissues placed in sandy loam and heavy clay soils, respectively. Species of *Trichoderma* occurred in 75% and 100% of tissues, respectively, buried in sandy loam and heavy clay soils.

Seventy percent and 35% of one-node seed pieces planted in sandy loam and heavy clay soils did not germinate in 6 weeks in the greenhouse. *C. paradoxa* was isolated from more than 70% of the ungerminated seed pieces. *C. falcatum* was not isolated from the ungerminated seed pieces.

Pathogenicity tests. All tested isolates of C. paradoxa were moderately to severely pathogenic to stalks of the 3 cultivars. The isolates of C. falcatum attacked stalks of CP 52-68 and CP 65-357 slightly to moderately. The reaction of L 62-96 to C. falcatum was not consistent; some stalks were moderately susceptible, while others were resistant. Stalks of the 3 cultivars were also attacked, though slightly, by the isolates of F. moniliforme. The buds of infected internodes were killed by these 3 pathogens. Although F. solani and species of Trichoderma occasionally spread to adjacent internodes from the site of inoculation, they did not kill the buds. The isolates of C. paradoxa, C. falcatum and F. moniliforme were recovered from the inoculated stalks.

DISCUSSION

Although 11 species of fungi were isolated from the ungerminated seed pieces of the 3 sugarcane cultivars, only 3 species, C. paradoxa, C. falcatum, and F. moniliforme, were pathogenic to the buds of seed pieces. Isolates of C. paradoxa and C. falcatum were more detrimental to germinations of seed pieces than isolates of F. moniliforme. Species of Trichoderma and F. solani were slightly pathogenic to the inoculated stalks even though they did not kill the buds.

Ceratocystis paradoxa occurred most frequently in the ungerminated seed pieces of the 3 cultivars and in soils. This pathogen was especially common in ungerminated, hot-air-treated seed pieces and in sandy loam soil, whereas C. falcatum was observed only rarely in the ungerminated, hot-air-treated seed pieces. Although there are many factors influencing bud germination, C. paradoxa in soils is among the more important factors responsible for reducing the germination of hot-air-treated seed pieces.

Edgerton (6) reported that pineapple disease in Louisiana occurred only occasionally during winter when the temperature was low while the seed canes were more or less inactive. Isolation of C. paradoxa from more than 95% of ungerminated seed pieces of CP 65-357 and from soils collected in November, 1974, indicates that this pathogen could infect seed pieces of some present commercial cultivars in late August and early September. The pineapple disease in Puerto Rico also occurred mostly in the summer when the soil moisture was below 22.5% and the soil temperature was 22 to 32 C (7). This is the first report on the infection of planted seed pieces by C. paradoxa in the summer in Louisiana.

The severity of pineapple disease in planted seed pieces is greatly affected by soil and weather conditions that retard the germination of the buds or the growth of young shoots (6). When seed pieces are planted in soils with low moisture in late August or early September, bud germination is delayed, and growth of C. paradoxa in seed pieces is favored.

Colletotrichum falcatum was isolated rarely from the ungerminated, hot-air-treated seed pieces. The rare isolation of C. falcatum suggests that C. falcatum was inactivated by heat treatment of the seed pieces. The inactivation of C. falcatum by hot-air-treatment of short seed pieces has been reported from India (9).

All the commercial cultivars of sugarcane in Louisiana are screened for their reaction to C. falcatum. The 3 cultivars ranged from moderately susceptible to very resistant to C. falcatum (3, 4, 5). The reaction of the 3 cultivars to C. paradoxa and F. moniliforme is still unknown. The results of present studies seem to indicate that the 3 cultivars are susceptible to C. paradoxa and resistant to F. moniliforme.

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FOREWORD

A minor change has been made in the format of Volume 7 of the Proceedings. Alphabetical lists of authors and titles of papers actually printed in the Proceedings have been substituted for the programs of meetings that were included in earlier volumes. Separate lists have been provided for papers dealing with agricultural and manufacturing topics. Since manuscripts of many of the papers presented orally at meetings of the Society in 1977 were not submitted for publication in the Proceedings, these programs would not have provided reliable references for papers included in the Proceedings. It was the editor's thought and hope that the lists of authors and titles would prove more useful to readers of the Proceedings.

A further reason for the change is the publication in the Proceedings of several articles which were not presented at meetings, consequently would not have been listed in the programs. The authors and titles of these papers have been included in the lists and the manuscripts have been printed in the Proceedings without identification.

Due to the unfortunate absence from the Proceedings of numerous papers which were presented at the meetings and the fortunate inclusion of several papers which were not presented at meetings, this publication is not in a strict sense the proceedings of our meetings held in 1977. Consequently, the ASSCT may wish to consider changing the title from Proceedings to a more appropriate one, such as Journal or Bulletin.

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PRESIDENT'S MESSAGE: LOUISIANA DIVISION

F. N. Bolton
Caldwell Sugars Co-op, Inc.

As Louisianians reflect on the 1976 crop year, our thoughts and conversations concentrate on many miserable memories. Seemingly by instinct, we recall the low prices that prevailed, the late November freeze, the excessive rain, the "weather" market, the tripling of the duty, the International Trade Commission, and our hopes and anxieties that our government will have the foresight to implement a workable long-range domestic sugar program.

We are told that, as one is faced with death, one seems compelled to look very closely at life. Perhaps, if we closely examine the 1976 crop year and re-live some of these miserable memories, then, hopefully, this exercise will make us more objective in our recall and better sugar technologists in the future.

For the 1976 crop year, Louisiana produced a very respectable 646,000 tons of sugar, in spite of adverse weather conditions throughout the harvest. An estimated 50,000 tons were lost due to processing freeze-damaged cane, wet field conditions and abandoned acres.

Early in the growing season, reports indicated a good crop potential. Stubble fields were generally good and only some gappy fields of plant cane were noted. The crop was shorter, but this was being offset by better population counts. Some reports were published indicating that growers were very optimistic, which is generally bullish news.

When the crop prognosticators began their annual volley of figures, a most notable one stated it would be difficult to yield a state average of more than 22 net tons per acre. This was followed by early harvest reports that cane per acre was running two to four tons better than expected. Some areas of the sugar belt were indicating prospects of record-yielding tonnages.

The picture was being painted for a very high-yielding crop until the severe freeze November 30. Freezing temperatures for nine to 11 hours hit the entire sugar belt with approximately 100,000 acres still unharvested. All the cane suffered severe internal tissue damage, and some isolated freeze cracks were sighted. Within a short time, it became apparent to everyone that cane quality was deteriorating. Only through unprecedented grower and processor cooperation, and sheer determination by both, were abandoned fields minimized.

Let us examine the lessons here for our memories. First, we remind the crop prognosticators of the old Louisiana legend--"When the crop looks good, it is better; when it looks bad, it is 'worser'."

Second, it is obvious that the importance of good harvesting practices and the influence it has on preserving cane quality was vividly demonstrated this past year. Without minimizing the delays in the cut, burn, delivery and grinding processes, perhaps few mills would have continued to operate beyond December 15, two weeks after this freeze.

Now, the question is: why these delays? The answer is that our method of evaluating cane quality rewards and penalizers growers first on the basis of trash content, then juice quality. Both of these are critical processing criteria under the important category of recoverable sugars.

Today, only the core-sampling system, which uses recoverable sugars, can relay to Louisiana growers an understandable message that can be properly translated into improving their harvesting techniques. The present sampling system cannot do this. Threats of mill closure are the only method under the present system that has been effective in improving cane quality following freezes.

Finally, excessive rain and the corresponding wet field conditions have been judged the primary culprit for most abandoned fields. With dry weather following this past freeze, it is felt that a complete harvest would have been entirely possible.

Now, let us turn our memories to the market. For the first several months, prices moved sideways in the US$ 0.15 to $0.16 range. Stories about the "Russians are coming," the long-term Philippine sales, relieving storage of sugar in school gymnasiums and swimming pools, and the Dominican refusal to sell their large surplus at prices below $0.17, were market pacifiers during this time.

In early May, the market was pushed to a year's high of $0.1725 following spectacular interest. Then, the weather in Europe took over as main supporter, until July. Dry weather in Western Europe had caused some to lower France's production by almost 1.0 million tons. One report stated that, in order to replenish losses to subsurface water levels, six months of heavy rain would be required. Another said that if rain did not occur by July, as much as 20% of the European Economic Community crop could be lost.

.These reports caused much speculation in predicting the 1976-1977 world sugar production. News items only mentioning that rain was forecasted in Europe sparked selloffs that sent prices down some days. To demonstrate the utter confusion, an actual trading strategy during a five-day period in mid-July went from a sideline position, because of bearish weather reports, to long, then short, then side-lined or closely stopped.

Soon, the nutshell game on weather began evaporating as news of rain in Europe began dampening the market's enthusiasm. This, coupled with later reports of a good beet crop in the U.S.S.R., favorable weather in cane areas, and preliminary beet test results, formed a downward pattern that reached a low of $0.089 in September.

At this point, we must stop to evaluate this miserable memory. First, always remember that sugar producers and speculators are noted for exaggerating prospects when conditions are less than favorable. Second, and this is mainly for our political leaders and consumer advocates, the price stability everyone hopes for and talks about is near impossible in the world sugar market arena. The world market is simply supply and demand, and, because of the simplicity and apparent lack of economic confusion, it has become difficult to comprehend.

The world sugar market is the residue of other markets and predicting price limits on either end is purely science fiction. On the trip down last year, or the roller coaster ride, as it has been called, it became obvious that, regardless of the break-even point, the pressure of full warehouses, the need for foreign exchange and the desire by some to establish reliable markets for the future finally prevailed in the decisions to dump sugar before prices went even lower.

What is predictable though, is that the increasing sugar consumption will eventually overtake production in this open market, because low prices and high capital costs cannot encourage increases in production. In Dr. Viton's opinion (Sugar y Azucar, March, 1977) the longer the low prices, "the greater will be the price explosion." Many subscribe to this theory, so keep it in your memories.

Politically, 1976 and the months thus far into 1977 have been confusing and frustrating. Last July, the Ford administration advocated an open-market policy for sugar which seems to appeal to some as a means of achieving low prices today--forget tomorrow. Then, last September, he raised the duty and called this an "interim measure," pending receipt of the International Trade Commission (ITC) findings. Hopes for Executive action were at flood stage in Louisiana as the President's campaign sailed down the Mississippi River on a steamboat.

The hope did not linger long following the vote in November. Given a new administration and new people to do business with, speculation began on the role of the new Secretary of Agriculture. When Bob Bergland was confirmed, hopes were on the increase again, for there was sugar man publically committed to preserving the domestic sugar industry.

Frustration began surfacing again with the delay of the ITC finding, brought about by the refusal of the high-fructose corn producers to provide financial data. Their actions signal their confederate policy in the U. S. sweetener industry, where they temporarily enjoy an advantageous position only because of low corn prices.

In spite of the delay, the finding confirmed the evident, i.e., that the domestic sugar industry was being adversely affected by sugar imports. Again, hopes increased, followed by later frustration when the new administration failed to act pending the outcome of the International Sugar Organization talks in Geneva. Unfortunately, due to publishing deadlines, this paper cannot await the results of these talks, as interesting as they may be.

So, politically, our memories should remind us that this course of action will always gain sympathetic responses, but slow-moving action. Logical solutions create complex problems in other areas and, frequently, the catastrophic must occur to expedite the solution.

Yes, 1976 in the sugar belt of Louisiana was a "ripoff" year. However, we literally weathered this year with a minimum of casualties and economic scars that may take several years to heal. However, doom is not as near as some may predict, because, since sugar was first introduced in Louisiana, a kind of romance developed that manifests itself in creative ways. This romance will continue to survive by increases in yield, as well as in mill capacity and efficiency, labor productivity, more intense marketing and product development, along with more integration of the overall industry.

These are not casual words to conclude remarks. These are facts, because these actions have already begun.

PRESIDENT'S MESSAGE: FLORIDA DIVISION

Larry G. Fowler
Sugarcane Growers Cooperative of Florida

For Mainland sugarcane growers and processors, the 1976-1977 harvest season could rightfully be termed the one most adversely affected by weather in recent years. The rain hampered harvest in Texas and the freezes in Florida and Louisiana remind us that production estimates can very seldom be counted upon. The Florida sugar industry has just completed its harvest season, the result of which failed to meet the expected production from pre-crop estimates.

Preliminary figures show that the eight raw sugar mills on the southern shores of Lake Okeechobee ground 9,919,000 tons of sugarcane, harvested from some 300,000 acres. A total of 927,000 short tons of 96-degree sugar were recovered from our processing efforts, with approximately 69 million gallons of blackstrap molasses produced. The pre-crop estimate, released in mid-November, 1976, had indicated an expected production of 1,050,000 short tons of raw sugar, and this estimate was raised to 1,100,000 tons in early January, just prior to the severe freeze.

The reduction in sugar produced due to "Mother Nature" and the current price of sugar, which has been well below average production costs since August, 1976, have not made the 1976-1977 crop season one of the brighter times in Florida sugar history. With the disappointments of the 1976-1977 crop behind us, what does the future hold for the Florida sugarcane industry, and what must be done, since we now have to operate under a new set of conditions?

It is premature, at this point in time, to estimate the damage caused by the January freeze on young planted cane for next season's harvest. It is fairly conclusive that some losses will be incurred, since most of the young plant cane was frozen back to the ground, which caused substantial losses in growth. Should optimum growing conditions prevail until next harvest season, some of this lost growth could be regained; however, some losses in sugar production for the 1977-1978 harvest season are evident.

The recent low sugar prices indicate the stabilizing effect the Sugar Act had on the domestic sugar industry. Without the Sugar Act or any type of sugar legislation in existence, the long-term effect on domestic sugar production is extremely difficult to assess.

With the uncertainty over the future price of sugar and no legislation in existence for a stabilizing effect, marketing and expansion conditions are very unstable. As everyone understands, producing cane sugar is a very difficult and expensive endeavor prorated over a long period of time. This fact has a large bearing on future sugar production, and the non-existence of a price-stabilizing factor puts immediate future expansion in a very vulnerable and speculative position.

There seems to be only one defense which established sugarcane processors and growers have against low sugar prices and that defense is to strive to attain the most efficient operation possible by reducing production costs and increasing productivity in all phases and aspects of their operations. Efficiency in every facet of our industry has suddenly become a necessity, rather than a desired accomplishment.

We are very proud of the accomplishments achieved by the Florida sugar industry since its inception and the progress made in recent years. Because of the unique soil conditions, the principals of the industry over the years have developed their own methods of planting, cultivation, harvesting and cane transporting. The grinding rates of Florida mills are higher than those in most sugar-producing areas of the world, and these high rates, coupled with total sugar recovery, provide maximum returns to the industry.

Even though the Florida sugar industry appears to possess one of the most efficient cane sugar operations in the world, there is much that can and must be done in order to increase productivity and reduce each unit operating cost.

From an agricultural standpoint, we must continue to search for new cane varieties which give maximum returns for our efforts, in terms of sugar per ton of cane and increased field yields.

The sugarcane variety development program in Florida, which is a three-part effort between the Florida Sugar Cane League, the U.S.D.A. Agricultural Research Service, and the University of Florida Agricultural Research and Education Center, provides for the breeding, selection, testing and distribution of new sugarcane varieties. The performance of future sugarcane varieties developed through this program will not only be a factor in future sugar production in Florida, but also will play a great part in the successful development of mechanical harvesters for Florida's unique conditions.

Cane varieties with physical characteristics applicable to mechanical harvesting will become a necessity in order to minimize losses in the field and in the mills as the Florida sugar industry turns toward total mechanization.

During the past harvest season, about 28% of the total crop was harvested by mechanical means, with percentages varying at the different mills. Machines of all types and manufacture were operated with varying degrees of success. However, immaturity of the cane during the early part of the harvest season, along with the freeze conditions which prevailed in January, coupled with the inability of the machines to selectively top the cane under recumbent conditions, had a detrimental effect on total sugar recovery.

The turn toward mechanical harvesting is not a means of increasing productivity or improving sugar recovery, but it is a defensive reaction to combat the rising costs of labor. From an overall viewpoint, mechanical harvesting in Florida will require a great deal more research before an acceptable machine can be developed for our unique conditions. As mechanical harvesting becomes a reality in our industry, more attention must be focused upon the planting and cultivation of our crop. This is one area within which immediate production increases can be realized as mechanization dictates more precision in these operations.

Increased efficiency in the control of insects, weeds, rodents and water are other agricultural activities which can immediately improve our field yields and productivity. We must exert every effort to increase our efficiency in harvest planning, scheduling and cane handling, in order to reduce the time lapse between harvesting and grinding and, thus, keep sucrose deterioration to an absolute minimum.

From the processing standpoint, we must analyze our mill operations for efficient energy use and balances, along with reducing total losses throughout the mill. With energy use being paramount in the minds of all Americans at this point in time, it will be necessary to expend every effort to be most resourceful in this area of our operations.

As in our agricultural practices, we must keep in mind that mechanical harvesting will dictate changes in mill equipment, operations and practices, due to the introduction of increased quantities and types of extraneous materials into our processes. We must anticipate and be prepared for these changes, since they will become more evident with increases in mechanically harvested cane.

We must also be prepared to expend the valuable time of managerial and technical personnel, along with capital funds, to incorporate changes in operational practices and equipment in complying with federal, state and local laws and regulations pertaining to the environment.

In order to successfully increase efficiency in all areas of our industry and remain in a viable position, it will be necessary to gain increased assistance from our supporting industries. With the changes facing the industry in the near future, it will be pertinent to call upon these supporting industries for their innovations and inventiveness to improve and make more efficient our agricultural and milling equipment, as well as practices and processes.

From an industry standpoint, we must continue to promote and seek new uses for our product. There are presently many uses for sugar and its by-products, and we are continually finding additional uses through intensive research. In these times of energy concern, sugarcane may well play a vital part in solving problems concerned with energy conservation as a potential fuel source, while continuing to supply food, chemicals, feed, paper and building products.

As an industry, we must continue and intensify our programs to educate the general public and our consumer-oriented government about the importance of the role of domestic sugar industry plays in the lives of the American consumer. Since there are no guarantees of a stable flow of foreign sugar into the American market, the importance of a viable domestic sugar industry cannot be overly stressed.

Our industry's greatest asset is its people. Nowhere else can be found a group of more dedicated, informed, educated and productive individuals than in the domestic cane sugar industry. Thanks to our scientific efforts over the years, we have amassed a great supply of information and technology, the utilization of which presently provides our growers with the ability to produce maximum sugar per acre and our processors to recover maximum sugar per ton of cane.

Even though the high degree of productivity per man-hour we achieve is among the highest of any cane-growing area in the world, we must keep in mind that to become complacent under our ever-changing industry conditions could be disastrous. The preservation of our industry will depend on creativity, innovation and the ability to accept change. We must continually make improvements and changes which will increase producitivity and lower our unit operating costs. In the domestic sugar industry, increased efficiency in all areas will be the key to success.

TECHNICAL PAPERS

1. Agricultural
2. Manufacturing

PREDICTING TONS OF SUGARCANE PER ACRE USING SOLAR RADIATION, TEMPERATURE AND PERCENT PLANT CANE, 1971 THROUGH 1976

R. J. Allen, Jr., G. Kidder, and G. J. Gascho
Agricultural Research and Education Center
Belle Glade, Florida

ABSTRACT

Radiation data expressed as average daily Langleys for the grand growth period, combined with annual growing season temperature expressed as degree days, can be used to derive relatively accurate equations for predicting tons cane per acre (TCA) for the Florida sugarcane industry. In addition to industry-wide prediction equations, individual equations have been derived for four mills. Adjustment of Langleys improved the equations but, except for one mill, adjustment of degree days did not. Adding percent of acreage in plant cane (PC) improved the equations for industry and for two of the mills where PC has relatively wide year to year variation. Industry TCA change factors were calculated to assist producers in comparing their estimates to predicted industry TCA.

INTRODUCTION

Earlier work (1, 2) showed considerable variation in solar radiation from year to year and a high positive correlation between incoming solar energy and tons of cane per acre (TCA). The reports also showed that solar radiation could be an important tool for making more accurate preharvest estimates of TCA.

Based on 9 years of data (1), it was calculated that a change of one Langley unit per day (LY) for the sugarcane grand growth period of April through October changed average TCA 0.16 for the Florida cane industry. When applied to Belle Glade 1971-75 radiation data, this factor was not reliable for individual years. The objectives of this study were to determine if an accurate method could be developed for predicting tonnage yields of sugarcane for the Florida industry and to determine and test prediction equations for specified portions of the industry.

Of the many variables which could be interacting with radiation, temperature and percent of acreage in plant cane (PC) were considered to be of major importance and were chosen for further study. The influence of crop management was considered to be minimal due to the generally consistent level of technology practiced in the Florida sugarcane industry. Frost and storm damage were not studied since, with the possible exception of the 1971 crop following the January 1971 freeze, neither has significantly affected area-wide tonnage. Water stress is also of minor importance in the Glades area due to generally good water control, which assures drainage if necessary and adequate moisture from sub-irrigation if rainfall is insufficient during the growing season.

Since plant cane produces higher tonnage than ratoon cane, the PC variable has an effect on average TCA, but it is not possible at this time to assign a definite value to this difference other than percent of total acreage. Further study of the PC variable is necessary.

Year-to-year variation in monthly averages of daily mean temperatures is greatest from December through February, and least from June through September (Table 1). Variations in March and April are intermediate but this could be quite important, since a higher or lower average during these months would mean an early or late spring and a longer or shorter growing season. October and November variation is also intermediate, but could also be important in prolonging or shortening the growing season, May through August.

Table 1. Monthly degree days of mean temperature above 60 F at Belle Glade AREC with no subtraction for daily means below 60 F.

	Year					
Month	1971	1972	1973	1974	1975	Ave.
	- - - - - - - - - - - - -Total degree days - - - - - - - - - - - - -					
Jan.	191	294	225	330	296	251
Feb.	209	185	80	148	289	182
Mar.	220	270	320	248	305	273
Apr.	306	375	324	327	399	346
May	484	496	513	529	561	517
Jun.	543	582	584	561	591	572
Jul.	617	624	636	608	625	622
Aug.	626	647	631	623	644	634
Sep.	564	592	615	622	603	599
Oct.	521	502	474	409	518	485
Nov.	312	341	370	276	288	317
Dec.	333	268	174	180	168	225

MATERIALS AND METHODS

Radiation and temperature measured at the Belle Glade AREC were used for this report. Data for 1971 through 1975 were reported previously (2); data for 1976 and 1977 are shown in Table 2. Degree days above 60 F presented in Tables 1 and 2 were calculated with no subtraction for daily means below 60 F.

Table 2. Belle Glade AREC radiation and temperature data.

	Radiation		Temperature	
Month	1976	1977	1976	1977
	- - - Ave. Langleys/day - - -		- - - - Degree days - - - -	
Jan.	307	286	116	76
Feb.	337	322	163	110
Mar.	445	441	343	366
Apr.	525	516	333	358
May	458	514	501	462
June	458	503	528	627
July	482	459	633	653
Aug.	460	442	636	664
Sep.	412	397	590	614
Oct.	360	365[1/]	431	478[1/]
Nov.	271		276	
Dec.	235		172	

[1/] 6-year averages for October.

Four parameters were calculated from the radiation and temperature data and all logical combinations of these were correlated using a maximum R^2 improvement multiple regression procedure. The four calculated parameters are described below and the values obtained are presented in Table 3.

Table 3. Data used for derivation of prediction equations (1971-75) and for making industry-wide estimates of TCA.

	Ave. daily radiation		Annual effective temperature			
Year	LY	ALY	DD	ADD	PC	TCA
1971	477	322	4108[a/]	3980	34	31.7
1972	471	325	5214	4617	33	38.1
1973	441	298	5009	4404	23	31.5
1974	418	284	5048	4412	23	29.0
1975	449	306	5287	4782	34	35.3
1976	450	307	4730	4302	30	31.4
1977[b/]	456	309	4226	4038	26	

[a/] Due to severe freezes in late January 1971, DD were accumulated only from February through October 1971.

[b/] Due to the freezes in January and February 1977, the 1977 DD were accumulated only from the first of March. The ADD were accumulated only from mid-March because of the exceptionally slow recovery of the cane during the colder than normal month of February. October values of all parameters were estimated as the 1971-76 averages for this month.

Average Langleys[1/] per day (LY) were calculated for the Grand Growth Period (GGP) of April through October for each year. The values used for October 1977 were the average of the previous six years.

Adjusted Langleys per day (ALY) were calculated for each year, by arbitrarily considering only a portion of the radiation of the different months of the GGP. The purpose was to give more importance to the radiation received in the latter part of the growing season than to that received early in the season. The adjusted Langleys per day were the average of 40% of April, 50% of May, 60% of June, 70% of July, 80% of August, 90% of September, and 100% of October average daily Langleys.

Degree days (DD) is a means of expressing effective temperature accumulated over a period of time. To calculate the degree days for a particular day the average of the maximum and minimum temperature of the day is determined. In this study DD above 60 F were summed from November of one year through October of the following year, i.e. planting through GGP. Daily means of 60 F or below were considered as zero degree days.

The Langley is the standard unit of solar energy and equals one gram calorie per square centimeter of surface.

Adjusted degree days (ADD) were calculated to account in part for the different periods of time to which plant and ratoon canes are exposed and take advantage of the warm temperature in the November to March period. The following formula was used to calculate ADD for each of the years studied:

$$ADD = G + P(a+b+c+d+e) = 0.125\ R(b+c+d+e) + 0.25\ R(c+d+e) + 0.25\ R(d+e) + 0.25\ R(e)$$

where G = degree days for Grand Growth Period,
P = percent plant cane,
R = percent ratoon cane
a, b, c, d, and e = degree days for November, December, January, February, and March respectively.

The percent of the acreage in plant cane was obtained from variety census reports (c.f., 3) and industry TCA from the Florida Sugar Cane League, Inc. (Table 3).

RESULTS AND DISCUSSION

The results obtained from the maximum R^2 regression procedure are listed in Table 4. One-variable correlations were not significant and were not listed. Very good correlation was found between TCA and the weather parameters, radiation and temperature. Coefficients of multiple determination (R^2) as high as 0.99 were obtained. Most of the regression equations were significant at the 0.05 level. Inclusion of percent plant cane generally improved the correlation from equations only considering the climatic variables.

Table 4. Regression results of the eight estimated equations for industry-wide TCA.

Equation No.	Constant	LY	ALY	DD	ADD	PC	R^2
1	-69.38	0.155 (0.0106)		0.00664 (0.000530)			0.992**
2	-62.43	0.136 (0.0158)		0.00643 (0.00046)		0.0811 (0.0583)	0.997
3	-56.59		0.204 (0.0120)	0.00552 (0.000429)			0.994**
4	-51.16		0.179 (0.00953)	0.00543 (0.00019)		0.0813 (0.0267)	0.999**
5	-65.62	0.125 (0.0187)			0.00949 (0.00148)		0.971*
6	-78.11	0.154 (0.0442)			0.0103 (0.00200)	0.126 (0.173)	0.981
7	-56.73		0.173 (0.0148)		0.00826 (0.000836)		0.990**
8	-65.42		0.206 (0.0156)		0.00869 (0.00048)	0.109 (0.0451)	0.998*

* Significant at 0.05 level.
**Significant at 0.01 level.

The predicted TCA and the actual TCA reported each year are shown in Table 5. Also shown are the average deviations of the actual TCA from that estimated, both by the eight formulas in each year and by each formula for the five years.

Examination of R^2 values in Table 4 and of average deviations in Table 5 indicates that the best equations for predicting industry-wide TCA is the one using ALY, DD, and PC. This is followed very closely by ALY-ADD-PC and LY-DD-PC.

In addition, TCA and PC data provided by four area mills were analyzed and predicted equations derived. ADD values were calculated for each mill according to individual PC figures. Eight equations for each mill, similar to those for industry, were obtained. Predicted TCA was compared with actual TCA for the five years 1971-75 and the deviations are presented in Table 6. Adding the PPC variable to the equations improved the estimates for the industry and for mills C and D but gave relatively little improvement for mills A and B. For mill A the only significant R^2 value was for the equations using ALY and ADD, but the smallest average deviation and the smallest range are for LY-DD-PC. For mill B there was little practical difference between the first four equations although ALY-DD had slightly less range. Mill C was the only one for which ADD gave better estimates than DD, with the LY-ADD formula being the only one for individual mills which had high statistical significance (1% level). However, the slightly less significant (5% level) LY-ADD-PC equation gives a much lower average deviation and much less range. The best mill D formulas are the same as for industry, ALY-DD-PC followed by ALY-ADD-PC and LY-DD-PC.

Table 5. Actual TCA and TCA estimated by eight prediction equations for five years, and average deviation of estimated from actual yields.

		Parameters included								
Year	Actual yield	LY DD	LY DD PC	ALY DD	ALY DD PC	LY ADD	LY ADD PC	ALY ADD	ALY ADD PC	Ave. dev.[1]
	-Tons cane per acre-									
1971	31.7	31.62	31.70	31.66	31.68	32.00	31.76	31.94	31.73	0.10
1972	38.1	38.03	39.92	38.36	38.14	37.30	37.52	37.73	37.99	0.30
1973	31.5	32.03	31.70	31.73	31.38	31.51	31.98	31.29	31.67	0.24
1974	29.0	28.74	28.82	29.09	29.08	28.70	28.52	28.92	28.86	0.20
1975	35.3	35.10	35.48	34.89	35.21	36.10	35.83	35.79	35.41	0.35
Ave. Dev.[2]		0.23	0.15	0.21	0.07	0.44	0.41	0.28	0.11	

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[1] Average deviation of eight formulas for each year.

[2] Average deviation of each formula for five years.

Table 6. Average and range of TCA deviations between estimated and actual TCA (1971-1975) for the Florida industry and four individual mills.

Variables	Industry	Mill A	Mill B	Mill C	Mill D
LY-DD	0.23 0.07-0.53	0.90 0.18-1.94	1.36 0.11-2.87	1.33 0.49-2.89	0.75 0.10-1.67
LY-DD-PC	0.15 0.00-0.20	0.71 0.18-1.34	1.36 0.11-2.72	0.32 0.05-0.58	0.50 0.03-0.87
ALY-DD	0.21 0.04-0.41	0.77 0.04-1.58	1.34 0.30-2.52	1.49 0.52-3.27	0.64 0.24-1.38
ALY-DD-PC	0.07 0.02-0.12	0.78 0.14-1.47	1.33 0.22-2.65	0.52 0.05-1.02	0.13 0.01-0.27
LY-ADD	0.44 0.01-0.80	1.30 0.34-2.36	1.85 0.32-3.03	0.44 0.12-0.77	1.24 0.51-2.16
LY-ADD-PC	0.41 0.06-0.57	1.25 0.21-2.02	1.83 0.21-3.08	0.15 0.00-0.28	0.76 0.09-1.14
ALY-ADD	0.28 0.08-0.49	1.11 0.08-1.93	1.76 0.52-2.79	0.75 0.02-1.32	1.10 0.46-1.81
ALY-ADD-PC	0.11 0.03-0.17	1.10 0.04-1.91	1.64 0.03-2.87	0.39 0.02-0.79	0.28 0.01-0.50

The predictive value of the equations was tested for the 1976 crop prior to its harvest. Use of the three equations which had produced the smallest deviations from predicted values in the 1971-75 period (Table 5) resulted in predicted TCA values of 32.0, 31.9, and 31.7 TCA for 1976. The average of all eight equations was 31.8 TCA with a range of 31.4 to 32.0. The 1976 industry-wide TCA was 31.4, very close to the predicted values. It is probable that the killing freezes of late January 1977 resulted in more severe topping of cane at harvest and lower tonnages delivered to the mills.

The prediction for 1977 industry-wide TCA as of October 1, 1977 was 29.3 by the best prediction equations ALY-DD-PC. The average of the four equations using DD was 29.2. For the four equations using ADD the average estimate was 30.1 TCA. The difference of 0.92 tons is due to the fact that the average difference between DD and ADD data for the five years used to develop the prediction equation was 494, while the difference in 1977 is only 188. There is some question as to whether equations using ADD based on non-freeze years are valid for a freeze year estimate.

While it is of considerable value to the industry and other entities to have an accurate estimate of cane tonnage to be harvested, it is of particular interest to a sugarcane grower to have an accurate estimate of his own production. Obviously, the more closely a grower's TCA resembles the TCA figures used in developing a predictive equation, the more likely he is of getting a reliable prediction.

Examples of this can be seen in Table 7 where separate equations were developed for each of four mills. Calculation of predictive equations for individual farms is possible when accurate production records are available.

Table 7. Industry estimates, actual tonnage and change factors.

Current year	Estimated[1] industry TCA	Industry TCA for previous year	"Change[2] factor"
1972	38.14	31.7	1.203
1973	31.38	38.1	0.824
1974	29.08	31.5	0.923
1975	35.21	29.0	1.214
1976	32.04	35.3	0.908
1977[3]	29.3	31.4	0.933

[1] Estimates are from industry prediction equation using ALY-DD-PC.
[2] Calculated by dividing estimated industry TCA by the industry TCA for previous year.
[3] As of October 1, 1977.

It should be rembered that the work reported here is based on only five years of data and despite the very good predictions which have resulted from use of the equations some caution should be exercised in using predicted values.

Everglades sugarcane growers for whom individualized prediction equations have not been determined may use the "change factors" presented in Table 7 to predict TCA production for their farms. The "change factors" were determined by dividing one year's industry TCA estimate by the previous year's actual TCA.

To make a 1977 prediction from this information, a sugarcane grower having 35.0 TCA average in 1976 would multiply 35.0 by 0.933 to get a 1977 prediction of 32.7 TCA. The grower would have to consider his PC relative to the 1977 industry-wide value of 25.6% for the 1977 crop, and how close his TCA has compared to the industry-wide trend over the past years.

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DE-FUZZING SUGARCANE SEED WITH A SMALL SEED SCARIFIER[1]

R. D. Breaux
U. S. Sugar Cane Field Laboratory
Agricultural Research Service, USDA
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

ABSTRACT

The whorl of long bristles that surrounds each sugarcane spikelet gives the sugarcane inflorescence a silky appearance and true seed of sugarcane a "fuzzy" character. When the seed viability is less than 50 per gram, a thick mat of fuzz must be sown to obtain an adequate plant population per flat in the greenhouse. Seedlings have great difficulty germinating in and growing through the thick fuzz mat, the control of fungi and bacterium is difficult, and many seedlings die when the mat dries between waterings. A small seed scarifier used at Houma removed these callus hairs from the sugarcane spikelets quicker and easier than any previously reported method. The defuzzed seed of six sugarcane crosses low in viability produced 40% more seedlings than untreated fuzz sown in thick mats.

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[1] Only the Abstract of the paper was available for the Proceedings.

INFLUENCE OF PLANTING DATE ON YIELD AND QUALITY OF SUGARCANE FOR SIRUP[1]

Dempsey M. Broadhead
USDA, ARS
Sugar Crops Field Station
Meridian, Mississippi

ABSTRACT

Experiments were conducted at Meridian, Mississippi from 1969-1975 to determine the optimum date for planting sugarcane for sirup production. Stalks of CP 36-111, CP 52-48, and CP 67-500 were planted on September 1, October 1, and November 1 to determine the effect of planting date on stalk yield and juice quality. Stalk yield in four plant cane crops was significantly higher from the September 1 and October 1 plantings than from the November 1 planting. Yield of stalks was similar from cane planted September 1 and October 1. Variety x dates of planting interaction was not significant for stalk yield. Stalk yield from first and second stubble crops was not affected by planting date. Brix was not influenced by planting date in plant cane or stubble crops.

INTRODUCTION

In Mississippi, sugarcane for sirup is usually planted in late October or early November. Consequently, the buds rarely grow and emerge before the following spring (March or April).

Stokes (1) showed that yield of cane from fall planting (October 15 or November 15) was equal to or higher than that from spring planting (March or April). Two varieties, Co 290 and CP 29-116, differed in their response to date of planting. Co 290, planted October 15, produced higher yield of cane than when planted November 15. Yield of cane from CP 29-116 was similar from October 15 and November 15 plantings.

The experiments reported here were conducted to determine the optimum date for planting CP 36-111, CP 52-48, and CP 67-500 sugarcane varieties for sirup production.

MATERIALS AND METHODS

Sugarcane was planted at Meridian, Miss. in 1968-72 on Ruston, fine sandy loam. The 1969 and 1970 experiments were destroyed by the effects of low temperature in January 1970. Plant cane only was harvested from the 1969 experiment and no harvest was made from the 1970 experiment. Three crops--plant cane, first stubble, and second stubble--were harvested from the experiments planted in 1970, 1971, and 1972.

The nine treatments resulted from combinations of three planting dates (September 1, October 1, and November 1) and three varieties (CP 36-111, CP 52-48, and CP 67-500). The design was a split plot with four replications. Main treatments (planting dates) were planted in three-row, 0.015 acre plots that were randomized in a complete block design. Subplots (varieties) were three-row, 0.005 acre areas. Approximately two lines of stalks (240 buds) were planted in each subplot. Plant counts were made after killing frost occurred in the fall and again in May or June in the spring.

At harvest, randomly-selected, 10-stalk samples were crushed in a three-roller mill to obtain juice for measuring brix (soluble solids) with a hydrometer.

RESULTS AND DISCUSSION

Fall emergence of sugarcane plants decreased with delay of planting date. Buds planted September 1 and October 1 had 35.7% and 7.5% fall emergence, respectively; those planted November 1 did not emerge in the fall (Table 1). Buds that grew and emerged in the fall and those that did not emerge until spring were affected similarly by winter temperature.

Yield of plant cane was significantly higher from plantings made September 1 and October 1 than from those made November 1 (Table 2). Plant cane yield was similar from sugarcane planted September 1 and October 1. The variety x date of planting interaction was not significant for stalk yield.

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[1] Cooperative investigations of the ARS-USDA and Mississippi Agricultural & Forestry Experiment Station, Mississippi State, MS 39762.

Table 1. Influence of date of planting on plant population of plant cane, 1969 and 1971-73.

Date planted	Number of plants per acre Fall	 Spring
September 1	17,158	60,858
October 1	3,587	50,691
November 1	0	42,287

Table 2. Influence of date of planting on stalk yield, 1969 and 1971-75.

Date planted	Crop Plant cane	 1st Stubble	 2nd Stubble
	- - - - - - - - -	-Tons/A-	- - - - - - - - -
September 1	42.6 a*	40.1 a	41.3 a
October 1	42.1 a	40.5 a	40.2 a
November 1	40.1 b	40.0 a	40.0 a

*Means within columns having different letters differ significantly at the 1% level by Duncan's multiple range test.

Yields of stalks from first and second stubble crops was not affected by planting date. Juice brix was not influenced by planting date in plant cane or stubble crops (Table 3).

Table 3. Influence of date of planting on brix, 1969 and 1971-75.

Date planted	Crop Plant cane	 1st Stubble	 2nd Stubble
	- - - - - - - - -	-Tons/A-	- - - - - - - - -
September 1	15.6 a*	16.5 a	17.1 a
October 1	15.3 a	16.5 a	17.0 a
November 1	15.4 a	16.5 a	16.8 a

*Means within columns having the same letters do not differ significantly at the 1% level by Duncan's multiple range test.

These data indicate the possibility of reducing the planting rates of sugarcane (two lines of stalks) by early planting (September 1). Additional experiments with planting rates (one, two, and three lines of stalks) x dates of planting should be made to verify this.

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EFFECTS OF WATER MANAGEMENT AND ROW HEIGHT ON SUGARCANE YIELD[1]

C. R. Camp
Agricultural Research Service, USDA
(In cooperation with the Louisiana Agricultural Experiment Station,
Baton Rouge, Louisiana)

ABSTRACT

The effects of water management and row height on a sugarcane, i.e., variety CP 65-357, were determined in an experiment initiated in 1973 in 0.01-acre concrete-bordered plots, on Mhoon silty clay loam soil, where water management treatments could be precisely controlled. Water-management treatments included maintaining a water table at a constant depth of one foot below the soil surface, which was drained to a depth of at least five feet, and on an undrained check area where the water table fluctuated naturally with rainfall. Row-height treatments included planting sugarcane in furrows opened on the conventional ridge, and a flat soil surface. During the 1974 plant crop, sugar yield per acre for the constant water table treatment was significantly higher than for the drained treatment. Plant population, sugarcane yield and sugar yield were significantly higher during the first ratoon crop (1975) for the drained treatment than for the constant and fluctuating water table treatments. Plant population, sugarcane yield and sugar yield were significantly higher during the second ratoon crop (1976) for the flat-planted rows than for the ridge-planted rows. Rainfall was higher than normal during 1975, but lower than normal during 1974 and 1976. The water table in the check area was high throughout most of 1975, particularly during the growing season. Since sugarcane rows in Louisiana are spaced closer together, to increase plant population, the planting furrow must be formed from a flat surface instead of on top of a ridge. As a result, the sugarcane seed piece and stubble will be much lower, in relation to the furrow, than they are in the present system. Damage due to poor internal soil drainage will probably occur more frequently for the flat-plant system if adequate drainage is not provided.

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[1] Only the Abstract of the paper was available for the Proceedings.

EFFECT OF WATER MANAGEMENT ON YIELD AND LONGEVITY OF SUGARCANE[1]

Cade E. Carter
Agricultural Research Service, USDA
Baton Rouge, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station,
Baton Rouge, Louisiana)

ABSTRACT

Five experiments were conducted on Louisiana State University's Research Farm in Baton Rouge during 1967-1975 to determine the response of sugarcane to water management. All experiments were conducted in 0.01-acre concrete-bordered plots on Mhoon silty clay loam soil. The experiments included: constant water tables during the growing season; constant water tables during the growing and dormant seasons; irrigation, followed by sub-surface drainage; saturating the soil profile for various durations; and varietal response to constant water tables. Experiments One through Four were conducted with the same variety, CP 55-30. In Experiment One, sugarcane yields from plots with constant water tables 24, 32, 40 and 48 inches below the soil surface were 56% greater than those from the check area, where the water table fluctuated. Yield differences among the four treatments were not significant. The number of high-yielding ratoon crops harvested from the treated plots was increased to four from the normal two. In Experiment Two, when the water table was maintained 12, 30 and 48 inches below the soil surface, only during the growing season, yields were not significantly different among treatments, but, when these same water levels were maintained during both growing and dormant seasons, cane yields were significantly reduced by high water tables. Cane yields were 15, 26 and 33 tons per acre from the 12, 30 and 48-inch water tables, respectively. In Experiment Three, sugarcane was irrigated when two-thirds of the water available to plants in the top two feet of soil had been depleted. This condition occurred five times in 1969 and three times in 1970, but did not occur in 1971. Yields from the irrigated plots were not significantly different from the non-irrigated plots. All plots were subsurface drained to a depth of five feet. In Experiment Four, the soil profile in the sugarcane plots was saturated for one, two and four weeks, followed by subsurface drainage to a depth of five feet for seven, six and four weeks, respectively. This cycle was repeated three times during each of the growing seasons in 1972 and 1973. The check plots were not flooded and were subsurface drained continuously to a five-foot depth. Cane yields were reduced 0.21 and 0.40 tons per acre for each one-day increase in flood duration in 1972 and 1973, respectively. In Experiment Five, sugarcane yields of varieties CP 48-103, L 62-96 and L 65-69 with a two-foot constant water table were similar to those from a four-foot constant water table.

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[1] Only the Abstract of the paper was available for the Proceedings.

AERATED STEAM THERAPY FOR CONTROL OF RATOON STUNTING DISEASE AND POSSIBLY SUGARCANE MOSAIC[1]

O. M. Cifuentes and R. J. Steib
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

An aerated steam (AS) treatment using 51 C for four hours to treat whole stalks with adhering trash was used for the first time in Louisiana in 1976 for control of the ratoon stunting disease (RSD) of sugarcane. Recent results under Louisiana conditions indicate seed cane stalks of four to five months of age are able to tolerate much higher temperatures and longer exposure periods than 51 C for four hours. Many varieties were treated at temperatures ranging from 51 to 57 C with exposure periods of from 2 to 12 hours. Treated stalks were cut into one-eye-pieces 3 inches long and planted under optimum growth conditions in the greenhouse. Whole stalks of similar treatments were planted in the field. Germination of all varieties was excellent for AS treatments at 51 C for eight hours, 52 and 53 C for five hours and 54 C for three hours, while 54 for four hours reduced germination by 25%. Field germination of whole stalks in all cases was superior to similar treatments in the greenhouse. Examination of four-month-old cane grown in the greenhouse revealed a very low percentage of stalks with doubtful mature RSD symptoms for treatments at 51 C for four hours, 52 and 53 C for four hours, and 54 C for three hours. Juice extracts from stalks of the above treatments are being checked for the presence of the bacterium found associated with RSD. Tolerance to the most severe AS treatments differed among varieties. After it was found that AS treatments at 51 C for eight to 10 hours and 54 C for five hours did not severely reduce germination of AS-tolerant varieties, treatments at 56 C for 2.5 to 3 hours, and 57 C for 2 hours were used to treat seed cane stalks infected with both RSD and mosaic. Mosaic is one of the most destructive virus diseases of sugarcane. With a treatment at 56 C for 3 hours, mosaic control was 100% in two varieties and 92% in a third. RSD was also effectively controlled. Germination was 55% for L 62-96; 67% for NCo 310 and 12% for heat-susceptible CP 65-357. The 56 C for 2.5-hour treatment improved germination over 56 C for 3 hours; however, it was found to be less effective in controlling mosaic in the same three varieties. With a treatment at 57 C for 2 hours, mosaic and RSD control was not as effective as at 56 C for 3 hours. This was possibly due to the reduced treatment period, which did not allow time for proper heat distribution among stalks being treated with all adhering trash. Preliminary results from 1976 tests indicate that AS therapy using high temperatures and shorter periods of treatment than necessary for RSD control may possibly be used to control other systemic diseases of sugarcane.

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[1] Only the Abstract of the paper was available for the Proceedings.

MECHANICAL SUGARCANE HARVESTER PERFORMANCE EFFICIENCY AND PRODUCT QUALITY WITH SELECTED SUGARCANE VARIETIES

J. E. Clayton, B. R. Eiland, J. D. Miller
P. M. Lyrene and H. H. Samol[1]

ABSTRACT

The mechanical harvester performance efficiency of nine sugarcane varieties was measured during a three-year sugarcane crop cycle in Florida. These varieties had diverse stalk and growth characteristics which represent Florida sugarcane. Performance efficiency and quality measurements were made on the center two rows of a four-row plot. Varieties were in a randomized block experiment, with three replications. The plots of each variety were rated for erectness by the researchers before and after preharvest burning. Harvester and transport traffic was kept uniform over the experimental plots. The varieties harvested efficiently without uprooting in the the plant cane crop. Some stalks of the recumbent varieties were uprooted during the first ratoon harvest and the harvester performance efficiency was lower in all varieties. Harvester efficiency was higher in the second ratoon crop because most varieties were erect. Variety CP 65-357 had the highest plant population and the highest harvester performance efficiency--averaging 96.7% over the three-year period. The average yield of this variety was 48.5 tons per acre. The average trash content of the varieties ranged from 7.4 to 16.6% over the three harvests. Stalk diameter, erectness, brittleness, yield, sugar content and other factors were measured in the experiment.

INTRODUCTION

Uniform rows of erect sugarcane are needed for maximum performance efficiency of a mechanical harvester. Varieties with small amounts of adhering leaves and with tops that are uniform in height, provide good conditions for mechanically harvesting clean sugarcane. Mechanical harvesters in Florida perform better in plant cane fields than in ratoon fields because the root system is firmer and the row of cane is narrow and continuous in the plant cane. High-yielding varieties can become recumbent in plant cane fields because of inadequate support by the roots in the soft muck soils. The stalks that are uprooted by windstorms are lost for subsequent crop production with hand or mechanical harvesting methods. Sugarcane breeders are continually developing varieties to meet new production and harvesting requirements (2).

Both gathering-type and recumbent-type harvesters, manufactured by seven companies, are used to harvest about 30% of the sugarcane in Florida. The remainder is cut by hand and picked up with a machine which chops and loads the windrows of cane. The gathering-type mechanical harvesters depend on croplifters for dividing and channeling the row of cane into the feeding system of the harvester. These machines usually do not have a provision for cutting matted cane from the adjacent row if it cannot be separated by the croplifters. The recumbent-type harvesters do not separate the cane, but merely cut through the tangled material with dividing knives as it is presented to the harvesters. The mat of cane is cut and lifted into the harvester by pickup drums or chains. The recumbent-type harvesters leave short pieces of cane as the row is divided, and the lifting mechanism must be wide enough to pick up these pieces on a subsequent pass through the field. Both types of harvesters use circular base cutters to cut the stalks from the root system. The rows must be relatively flat for both types of harvesters, especially when the cane is recumbent. The extent to which varietal characteristics affect performance efficiency depends on whether a gathering- or recumbent-type harvester is used.

This experiment was conducted to determine which varietal characteristics are important for maintaining crop production when using a gathering-type harvester. The results presented are from a plant crop and two ratoon crops using varieties representing the types of sugarcane grown in Florida.

MATERIALS AND METHODS

Nine varieties of sugarcane were planted on October 24-25, 1973 using commercial practices with a planting rate of two continuous lines of stalk. The varieties were: Cl 41-223, Cl 54-378, CP 56-59, CP 63-306, CP 63-588, CP 65-357, CP 66-1079, CP 68-1067 and L 61-49. These varieties were selected for a range of stalk and growth characteristics from commercial and unreleased varieties to determine their effect on harvester performance efficiency. Harvester and field transport traffic was kept uniform through the field to aid in determining which varieties respond best after mechanical harvesting.

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[1] J. E. Clayton and B. R. Eiland are Agricultural Engineers, Science and Education Administration, USDA, Belle Glade, FL; J. D. Miller is a Research Geneticist, Science and Education Administration, USDA, Canal Point, FL; P. M. Lyrene is a Plant Breeder, University of Florida; and H. H. Samol was formerly an Agronomist, Florida Sugar Cane League, Clewiston, Florida.

The experimental design was a randomized complete block with three replications. Field test plots were each 20 feet wide, 300 feet long and contained 4 rows. The test blocks were bordered with variety CP 63-588. Sufficient space was left between replications to allow turning of the harvesting equipment. The direction of the harvester travel through the field was not considered important and each replication was harvested in the same direction each year.

We counted mature stalks on 30 feet of each interior plot row on August 13 and October 11, 1974 for the plant cane crop. In the subsequent two harvests, the stalk counts were made after burning and prior to harvest on December 1, 1975 and December 7, 1976. Brittleness ratings were determined from deflection measurements made on October 11, 1974, with the brittleness tester developed in Louisiana (1). The two interior rows of each plot were used for determining cane yield per acre, average stalk diameter, total length of skips in a row (over 3 feet long), harvester performance efficiency, trash content and sugar content. Uncleaned sugarcane samples from the harvester were milled for juice analysis for the first harvest. Because of inconsistent sugar results, only clean cane pieces were milled for the second and third harvests. Sugar yields were determined from the juice analyses at Canal Point using appropriate Variety Correction Factors (VCF) (3, 4).

Erectness ratings were made independently by four persons before and after the cane was burned. A scale of 1-(erect) to 10-points (recumbent) was used. A rating of 5 indicated that the stalks were leaning at a 45 degree angle at the base. The stalk diameter and skip length measurements were made in the row before the passage of the harvester. The harvester performance efficiency was made by scrapping the cane from 50 feet of row immediately after passage of the harvester. The average yield of the two rows was used to calculate the harvester efficiency. The trash samples were taken by use of a tractor front loader equipped with a large plastic tub for obtaining approximately 150 pounds of cane.

The plots were harvested with a Massey-Ferguson 201[1] harvester for the first and third harvests. A Toft 300[1] harvester was used for the second harvest as the other harvester was not available. The plots were plowed out by the cooperator after the third harvest.

RESULTS

The plant populations per acre of mature stalks and the brittleness ratings of the nine varieties are shown in Table 1. Variety CP 65-357 had more stalks than any other variety and maintained 32,000 to 40,000 stalks per acre each year. Varieties CP 56-59, CP 66-1079 and L 61-49 also maintained their level of stalk numbers each year. Most of the other varieties had lower plant populations in the third harvest with CP 63-588, CP 68-1067 and Cl 41-223 dropping to about 13,000 stalks per acre and Cl 54-378 having only 5,000 stalks per acre. The brittleness ratings varied from 6.6 for variety CP 66-1079 to 10.4 for Cl 41-223. Varieties CP 65-357 and Cl 41-223, with brittleness ratings of 9.0 and 10.4, respectively, were more difficult to break.

Table 1. Summary of plant populations and brittleness ratings of nine sugarcane varieties, Belle Glade, Florida.

Variety	Plant 8-8-74	Plant 10-11-74	1st Ratoon 12-1-75	2nd Ratoon 12-7-76	Brittleness[1] Rating
CP 65-357	35,400	32,200	40,200	35,800	9.0
CP 56-59	28,500	17,000	19,800	17,300	8.1
CP 63-588	28,200	21,700	23,100	12,600	8.1
CP 63-306	31,400	26,100	27,500	21,000	8.2
CP 66-1079	29,000	26,400	25,400	27,300	6.6
L 61-49	24,100	25,600	25,900	23,600	8.2
CP 68-1067	22,100	22,900	23,200	13,200	7.4
CL 41-223	24,100	20,500	18,800	12,200	10.4
CL 54-378	28,500	18,000	16,300	4,900	7.3

[1] Average number of 1/8-inch increments of deflections before stalk broke, plant cane only.

Erectness ratings for the varieties ranged from 3.0 to 9.3 before burning and from 4.3 to 9.6 after burning in the plant cane crop (Table 2). They ranged in erectness from 2.4 to 7.9 before burning and from 5.4 to 9.4 after burning in the first ratoon crop. The erectness range was from 3.8 to 7.7 before burning and from 5.7 to 8.3 after burning in the second ratoon crop. Table 2 shows this comparison of the erectness ratings for the three years. In all cases, variety Cl 54-378 was the most recumbent for the first two crops. Three other varieties were similarly recumbent in the second ratoon crop.

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[1] Manufactured by Massey-Ferguson and Toft of Australia. Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by USDA or an endorsement by the Department over products not mentioned.

Table 2. Summary of erectness ratings, stalk diameters, and total skips of nine sugarcane varieties, Belle Glade, Florida.

Variety		Erectness rating		Stalk diameter (mm)	Skips (%)
		Unburned	Burned		
CP 65-357	Plant	3.0	5.7	24.3	24.9
	1st R.	4.4	7.3	22.6	34.0
	2nd R.	3.8	8.2	22.7	38.2
CP 56-59	Plant	4.4	5.2	27.6	28.8
	1st R.	4.4	5.7	25.7	51.1
	2nd R.	4.5	6.4	26.5	80.8
CP 63-588	Plant	7.4	7.9	29.1	13.1
	1st R.	4.7	6.7	30.1	46.0
	2nd R.	7.0	7.8	31.0	79.8
CP 63-306	Plant	6.0	7.9	26.3	9.1
	1st R.	5.2	8.0	25.3	31.9
	2nd R.	7.3	8.3	25.6	63.1
CP 66-1079	Plant	3.4	6.2	28.2	16.7
	1st R.	4.3	7.2	26.4	18.4
	2nd R.	4.0	6.8	24.8	40.5
L 61-49	Plant	4.0	4.9	26.4	30.2
	1st R.	2.4	5.4	25.0	35.3
	2nd R.	4.8	7.4	24.0	61.1
CP 68-1067	Plant	3.3	4.3	33.4	30.6
	1st R.	4.0	6.6	32.2	38.9
	2nd R.	7.7	8.0	31.6	64.9
CL 41-223	Plant	4.8	5.0	31.3	14.5
	1st R.	5.5	6.9	31.0	30.2
	2nd R.	5.0	5.7	31.4	75.8
CL 54-378	Plant	9.3	9.6	30.0	19.0
	1st R.	7.9	9.4	31.3	48.2
	2nd R.	7.0	7.4	30.5	89.8

Some varieties fell noticeably during burning, perhaps due to the removal of trash that supported the stalks or to relaxation of the supporting fibers as the result of the heat. Variety Cl 41-223 had very little change in rating before and after burning in the plant crop and changed slightly after burning in the first and second ratoon crops. Variety CP 56-59, with a rating of about 5 points, changed about one point after burning in the first two harvests. Variety CP 65-357, which was rather erect, fell after burning each year with a rating change of 3 points or more.

This experiment was planted on relatively soft muck soil and the varieties were probably more recumbent than in the general Florida growing area. We could not observe any damage to the stubble of the plant cane crop because of the passage of the harvester and transport over each row. The field was cultivated flat for the first harvest and it was easily kept flat by the harvester cutting blades. Stubble was removed by the harvester base cutters in the first ratoon crop. No satisfactory method of measuring the stubble removal could be devised by observing the row or by determining the amount of stubble loaded with the cane. There was little damage to the stubble in the second ratoon crop. There was a small visual difference in the harvesting efficiency due to the direction of travel in some varieties but each replication was harvested in the same direction each year.

The skips in the row that were longer than 3 feet were measured at harvest each year. These are recorded in Table 2 as the percent of the row where there was no cane. The amount of skips varied from 9.1 to 30.6 percent in the plant crop for the nine varieties. The skips ranged from 18.4 to 51.1% of the area in the first ratoon crop and from 38.2% (CP 65-357) to 89.8% (Cl 54-378) in the second ratoon crop. Seven of the varieties had skips which averaged 60 to 80% of the row length. The skips did not particularly affect yields in the plant or first ratoon crops, but severely affected the second ratoon crop yields. Some stubble loss in several varieties can be attributed to damage from rats and rabbits.

Varieties CP 65-357 and CP 66-1079, with 38 and 40% skips, respectively, averaged 42.6 and 39.3 tons per acre in the second ratoon crop, respectively. The average diameters of the stalks are shown in Table 2.

Variety CP 68-1067 had the largest diameter (32.4 mm) while CP 65-357 had the smallest (23.2 mm) average diameter over the 3-year period.

Table 3 shows yield, harvester performance efficiency, trash content, sugar content and sugar yield from the nine varieties in the experiment. Harvester performance efficiency was measured as the percentage of crop recovered by the harvester based on the scrap from the 50-foot plot. Harvester efficiency for the recumbent variety Cl 54-378 was 93.8% for the plant crop and 89.5% for the first ratoon crop as compared to approximately 98% and 95% for these 2 years for more erect varieties CP 65-357 and L 61-49. Six of the varieties harvested at efficiencies around 98% in the plant cane crop. In the first ratoon crop, five of the varieties harvested at efficiencies of 94 to 95% while others dropped to about 90%. This drop in harvester efficiency from plant crop to first ratoon crop can be attributed to the poorer root system of the ratoons and more recumbent cane. The harvester efficiencies for the varieties in the second ratoon crop ranged from 94.2 to 98.1% with four varieties approaching 98%.

Table 3. Average of yield, harvester performance efficiency, trash content, sugar content, and sugar yield of nine sugarcane varieties, Belle Glade, Florida.

Variety-year		Yield (tons/A)	Harv. eff. (%)	Trash content (%)	Sugar content (lbs/ton)	Sugar yield (lbs/A)
CL 41-223	Plant	56.7	97.7	11.1	152.3	8,635
	1st R.	37.6	90.9	14.3	215.3	6,960
	2nd R.	18.9	94.5	24.5	197.8	2,810
	AVG.	37.7	94.4	16.6	188.5	6,135
CP 63-588	Plant	55.6	97.9	7.8	178.2	9,908
	1st R.	34.4	90.6	9.5	258.2	8,050
	2nd R.	15.8	96.0	12.7	237.7	3,250
	AVG.	35.3	94.8	10.0	224.7	7,067
CL 54-378	Plant	44.4	93.8	10.4	200.5	8,902
	1st R.	30.6	89.5	11.0	221.8	6,170
	2nd R.	10.7	95.7	21.8	226.3	1,900
	AVG.	28.6	93.0	14.4	216.2	5,652
CP 65-357	Plant	53.9	98.1	8.0	152.7	8,230
	1st R.	48.9	95.0	6.0	235.5	10,790
	2nd R.	42.6	97.7	10.3	232.9	8,850
	AVG.	48.5	96.9	8.1	207.0	9,289
CP 56-59	Plant	47.6	98.3	9.3	172.9	8,230
	1st R.	35.7	93.6	8.4	207.8	6,800
	2nd R.	18.2	98.1	17.6	223.4	3,370
	AVG.	33.8	96.7	11.8	201.4	6,134
L 61-49	Plant	47.1	98.4	5.0	183.0	8,620
	1st R.	38.7	94.9	9.8	229.7	8.075
	2nd R.	25.2	94.2	11.4	220.0	4,960
	AVG.	37.0	95.8	8.7	210.9	7,218
CP 68-1067	Plant	59.8	96.8	5.6	193.0	11,550
	1st R.	47.2	89.7	5.7	245.1	10,920
	2nd R.	26.8	97.7	11.0	230.7	5,490
	AVG.	44.6	94.7	7.4	222.9	9,351
CP 66-1079	Plant	54.7	97.3	7.5	163.5	8,940
	1st R.	48.0	95.3	8.7	225.1	9,870
	2nd R.	39.3	97.8	8.0	220.9	7,980
	AVG.	47.3	96.8	8.1	203.2	8,930
CP 63-306	Plant	54.3	97.9	8.6	202.1	10,980
	1st R.	37.6	93.8	7.2	207.7	7,240
	2nd R.	21.8	96.5	12.0	226.6	4,390
	AVG.	37.9	96.1	9.3	212.1	7,530
GRAND AVG.		39.0	95.5	10.5	209.7	7,481

Variety Cl 41-223 had the highest trash content for the 3 years, averaging 16.6%, while the recumbent variety Cl 54-378 was second with a 14.4% average. Variety Cl 41-223 had a high degree of suckering and non-uniform growth characteristics while Cl 54-378 was too recumbent for removal of tops by the harvester. Some varieties contained 6 to 8% trash for the plant and first ratoon crops and contained 10 to 12% in the second ratoon crop. This increase occurred due to the low stalk population and the resulting low yields. Some varieties averaged 7 to 9% trash over the 3-year experiment.

Cane yields ranged from 44.4 to 59.8 tons per acre in the plant crop, from 30.6 to 48.9 tons per acre in the first ratoon crop and from 10.7 to 42.6 tons per acre in the second ratoon crop. Varieties CP 65-357 and CP 66-1079 maintained a yield of 42.6 and 39.3 tons per acre, respectively, in the second ratoon crop and averaged 48.5 and 47.3 tons per acre, respectively, over the 3-year period. Four of the varieties produced only 10 to 20 tons per acre in the second ratoon crop and averaged 28.6 to 37.7 tons per acre over the 3-year experiment.

The sugar yield data from the plant cane crop were highly variable and were not considered reliable because of the delays between harvesting and milling and the variable trash contents. By the time of milling, the samples harvested early in the experiment apparently had deteriorated, thus losing sugar. Several samples were cut by hand in the plant cane crop because of wet weather. Varying amounts of tops in the mill samples may also have affected sugar yield estimates because of unrepresentative samples. Clean cane pieces were selected and milled promptly in the first and second ratoon crops.

DISCUSSION AND CONCLUSIONS

The varieties harvested better than expected in the plant crop in view of the amount of recumbency. Apparently, the cane had a good root system that held the plants in the ground as the harvester gathered and pulled the cane into the harvester. The average harvester performance efficiency dropped 5 points from the plant crop to the first ratoon crop. This drop occurred because of a poorer root system in the ratoon crop with a resulting increase in recumbency. The harvester was not capable of gathering all the recumbent stalks. The harvester performance efficiency in the second ratoon crop was about 1 point lower than in the plant cane crop.

Some stalks were uprooted prior to harvest in the first ratoon crop and the harvester base cutters removed these roots. We observed that stubble had been removed and that stubble was in the cane in the wagon. We could not devise a method of measuring the damage done to the varieties by the harvester cutting mechanisms or by the travel of the harvester and wagon through each row of cane. Most rows remained flat throughout the 3 years and the ends of the rows were kept grassed with very little cane loss when the harvester entered and exited the ends of the field.

The growth characteristics of a variety such as Cl 41-223 are such that the stalks grow from the side of the row and are leaning so that they fall when they become heavy. Varieties which grow straight at the base, and varieties with larger numbers of stalks remain straight for longer periods or support the leaning stalks so that they are not recumbent. Some of the varieties became recumbent after burning, but there was space at the bottom of the stalks for the harvester base cutters and croplifters to cut and lift it properly.

The trash contents tended to increase with each harvest and this increase occurs because of several different factors: (1) lower plant populations and poorer burns because of less dry material available for combustion, (2) more green leaves and suckers available which slows burning by reducing combustion temperature, (3) more green growth because of available light and space in low plant populations, (4) green trash and suckers are more difficult to remove by the harvester, which reduces the cleaning effectiveness.

Sugar contents were generally lower in the plant crop and highest in the first ratoon. Sugar yields were generally higher in the plant crop and lowest in the second ratoon. Three varieties (CP 65-357, CP 66-1079 and CP 68-1067) produced 4.5 tons of sugar per acre while the other six varieties averaged less than 4.0 tons of sugar per acre.

The ability of stubble to remain in the soil intact while harvesting is the most important harvesting characteristic which we observed. Obviously, the amount of stubble removed or destroyed determines the future yield capacity of the field. Stubble was removed easier in the large diameter canes than in the smaller canes because they fell and pulled the stubble out of the soil. The second most important harvesting characteristic was that as the plant population decreases, the trash content increases for a particular variety. The harvester could not remove the green trash from the stalks from the low tonnage plots.

Vigorous growing canes which stubble well after harvesting will simplify mechanical harvesting operations. These types of sugarcane can be characterized as having high plant populations and smaller stalk diameters. Unfortunately, this implies that the fiber content of the cane will increase, which will require more power to harvest and to process.

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SEROLOGICALLY SPECIFIC ELECTRON MICROSCOPY DETECTS THE RATOON STUNTING DISEASE-ASSOCIATED BACTERIUM[1]

K. E. Damann, Jr., K. S. Derrick and A. G. Gillaspie, Jr.
Department of Plant Pathology
Louisiana State University
and
USDA
Beltsville, Maryland

ABSTRACT

Serologically specific electron microscopy (SSEM) was used for the detection and identification of the distinctive bacterium associated with ratoon stunting disease (RSD). An antiserum to the bacterium was made by injecting purified preparations of the bacterium into a rabbit at weekly intervals for three months. Parlodion-coated carbon-fronted electron microscope grids were floated on drops of the antiserum (diluted 1:500) for 30 minutes. Floating these antiserum-coated grids on drops of juice or vascular extracts from RSD-infected plants for three hours resulted in the attachment of the bacterium to the grid surface by a specific antigen-antibody reaction. SSEM did not require concentration of the RSD bacterium, as does the micropreciptin test for bacterial detection. The technique appears to be more powerful than quick drip electron microscopy, and it has been used to diagnose RSD.

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[1] Only the Abstract of the paper was available for the Proceedings.

SMUT THREATENS MAINLAND SUGARCANE[1]

J. L. Dean
Agricultural Research Service, USDA
Canal Point, Florida

ABSTRACT

Sugarcane smut, caused by the fungus Ustilago scitaminea, is characterized by the emergence of a slender, whip-like appendage from the region of the growing point of an infected plant. The black color of the whip is due to a layer of dark fungus spores that can be rubbed off in soot-like masses. These spores are normally disseminated by wind blowing from the smut whips to contaminate other soil and plant surfaces. Infection occurs through buds, usually when the buds are germinating, although it is claimed that the infection of dormant buds may occur, and that the infection may remain latent until the infected buds begin to grow. Young tillers may become infected as they emerge through smut-infested soil. The effect of the disease on the cane depends upon the degree of resistance of the cane variety, as well as the time at which infection occurs. Primary shoot infection of a very susceptible variety may result in a stunted grassy-appearing stool with many smut whips and no millable stalks. At the other extreme, a stool of a more resistant variety may show a single smut whip on a nearly normal millable stalk. Sugarcane smut has caused serious economic loss in some countries and little damage in others. In all cases, the disease has been brought under control in a few years by means of resistant varieties. It is important to determine the degree of resistance of the commercial varieties and the canes used as parents in breeding programs as early as possible. It is hoped that this information will be obtained about U. S. varieties before smut arrives on the mainland of the U. S. Long present in Asia and Africa, sugarcane smut first appeared in the Western Hemisphere in 1940, in Argentina. By 1957, the disease has spread to Paraguay, Brazil and Bolivia. In 1971, it was found in Hawaii. It appeared as a serious threat to the U. S. mainland when it was found on the northern coast of South America (Guyana) and invaded the Caribbean (Trinidad and Martinique), in 1974. The threat became acute when smut was found in Jamaica, 600 miles from the Florida industry, in November, 1976. Plans are currently being developed to test U. S. cane varieties for smut resistance in Jamaica. Because of the Jamaican quarantine requirements, testing will not begin until about September, 1978.

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[1] Only the Abstract of the paper was available for the Proceedings.

THE EFFECT OF N,N-BIS (PHOSPHONOMETHYL) GLYCINE ON SOME PHYSIOLOGICAL COMPONENTS OF SUGARCANE YIELD

G. Dill and F. A. Martin
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

The effect of N,N-bis (phosphonomethyl) glycine on photosynthesis, dark respiration, specific leaf weight and percent dry weight was examined during the latter stages of sugarcane crop development. On September 17, 1976, glyphosine, at a rate of 3.36 kg/ha, was applied to the variety L 62-96. Sampling was initiated on September 21, 1976, and continued at two-week intervals through November 16, 1976. Suppression of average photosynthetic and dark respiration rates, as well as an increase in percent dry weight, apparently resulted from the glyphosine treatment. No differences in average specific leaf weights were observed in this study.

INTRODUCTION

The development of commercial sugarcane ripeners to enhance yield has recently been a target of much interest in the sugarcane industry (1, 3, 4) . This paper deals with the effects of one such ripener, N,N-bis (phosphonomethyl) glycine (glyphosine) on some physiological components of sugarcane yield. Photosynthesis, dark respiration, specific leaf weight and percent dry weight of the variety L 62-96 were examined in the fall of 1976 after the application of glyphosine. The effects of this compound were monitored over a 10-week period and at five different leaf positions through the later stages of sugarcane crop development in Louisiana.

MATERIALS AND METHODS

Plots of several varieties were planted in a randomized block design in the fall of 1975 at the St. Gabriel Experimental Farm of the Louisiana Agricultural Experiment Station. Each block contained 2 plots each of the variety L 62-96. On September 17, 1976 N,N-bis (phosphonomethyl) glycine (glyphosine) at a rate of 3.36 kg/ha was applied to one of the L 62-96 plots in each block. The glyphosine was applied using a compressed CO_2 system mounted on ground equipment in an attempt to simulate aerial application. Sampling began September 22, 1976 and was done every other week over a 10-week period through November 16, 1976.

Whole stalk samples were cut in the morning approximately one hour after sunrise, transported to the laboratory, recut under water and stored until the time of measurement. Leaf positions were numbered using the method described by Van Dillewijn (7), where the top visible dewlap (TVP) is the +1 position. All leaves below the TVD are assigned subsequent positive values (+2, +3, ...etc). All leaves remained attached to the stalk until measurements were taken. Leaves at positions +1, +3, +5, +7, and +9 were examined in this study.

An open system was used to measure photosynthesis and dark respiration by net carbon exchange. Two leaf chambers were constructed out of plexiglass using 1,2-dichloroethane, a plexiglass solvent, and silicone sealant. Both chambers were built with a double bottom, the lower compartment was utilized as a constant temperature water bath, while the upper chamber was the leaf compartment. By flowing water through the lower compartment, a temperature of 30-32 C was maintained.

Leaves were detached from the stalk, recut under water, and the cut end left submerged throughout the measurements. The leaf blade was inserted into the leaf compartment to a point 6 inches above the junction of the blade and the sheath. The slits around the leaf blade at each end of the leaf compartment were then sealed with plastic adhesive.

Atmospheric air (370 ± 10 ppm CO_2) taken 20 feet above the ground was pumped into a 35 liter reservoir with a diaphragm pump. Each leaf chamber was supplied with a separate pump and reservoir. The air feed line was split upon leaving the reservoir so that samples of atmospheric air could be diverted to the infrared gas analyzer (IRGA). Before entering the leaf chamber, air was humidified (80% RH). Flow rates over the leaf were held constant at 1 liter per minute while light intensity was held constant at 4.3×10^4 lux with a mercury vapor light source.

Leaves were allowed to equilibrate 20-30 minutes in the light before photosynthetic measurements were made. When the concentration of CO_2 leaving the leaf compartment was constant, the leaf was considered to be equilibrated. Two layers of black felt were then placed over the leaf chamber to block out the light. Again, 20-30 minutes elapsed before the leaf reached equilibrium and dark respiration measurements could be made.

The leaves were then taken from the chamber and their area measured with a portable area meter. Fresh and dry weights were then taken. Specific leaf weight on a fresh weight basis, and percent dry weight were then taken from these data. All calculations were performed as previously mentioned (2).

A least squares analysis of variance with a split-plot arrangement of treatments was used to analyze the data. The treatment source of variation was analyzed on the whole plot, while the leaf and date factorial affects were analyzed on the split plot level. Through a series of orthogonal comparisons, specific statistical relationships between L 62-96 treated with glyphosine and its untreated counterpart were made.

RESULTS AND DISCUSSION

Differences in the net photosynthetic rate among harvest dates and those associated with the treatment by date interaction were observed to be highly significant ($>F_{\alpha} = .01$). Fig. 1 shows how L 62-96 treated with glyphosine and its untreated counterpart varied with respect to the net photosynthetic rates measured when plotted across harvest dates. In this case, glyphosine did appear to suppress net photosynthesis across the first three harvest dates, delaying and suppressing net photosynthetic activity in this experiment. Treatment differences themselves, however, were not significant. These data are in agreement with evidence presented by Rostron (6), who examined the effects of glyphosine on apparent photosynthesis. Rostron did report, however, that CO_2 uptake did appear to be limited in the glyphosine treatment. Average net photosynthetic rates for both treated and untreated L 62-96 are shown in Table 1. Again, although not significant, these data suggest that glyphosine might have suppressed average net photosynthetic rates when compared to the untreated rate. Significant differences between leaf positions were also not observed.

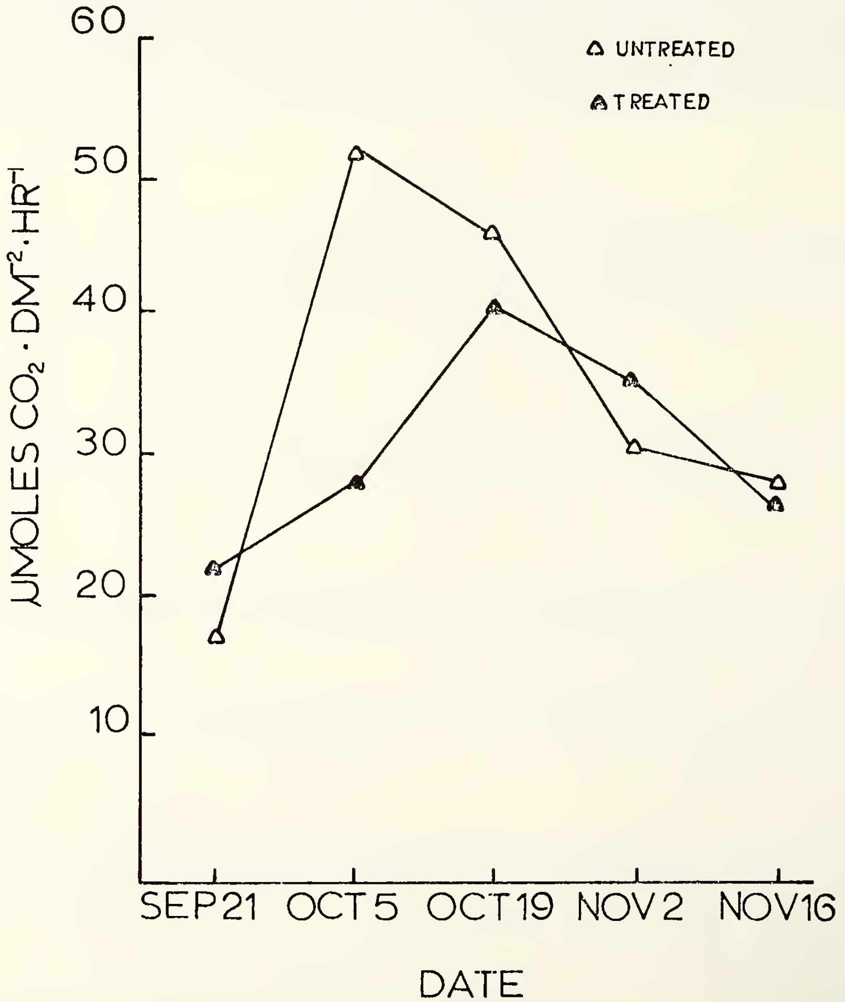

Fig. 1. Net photosynthetic rates of L 62-96 with and without glyphosine application as plotted across harvest date.

Table 1. Yield component averages over harvest dates and leaf positions for L 62-96.

Yield component	$\bar{X}$ Treated	$\bar{X}$ Untreated
Photosynthesis (μmole CO$_2$.dm^{-2}·hr^{-1})	33.86	30.26
Dark respiration (μmole CO$_2$·dm^{-2}·hr^{-1})	31.48	25.27
Specific leaf weight (grams·dm^{-2})	1.21	1.21
Percent dry weight (%)	36.85	35.11

Dark respiration rates plotted across harvest dates for both treated and untreated L 62-96 are shown in Fig. 2. Again, as in the case of net photosynthesis, glyphosine appeared to suppress dark respiration rates when compared to its untreated counterpart across the first three harvest dates. Both treated and untreated L 62-96 showed increase dark respiration rates over the last two harvest dates. As in the case of net photosynthetic measurements, treatment differences in dark respiration rates measured were also not observed to be statistically significant. Again, Table 1 indicates that on the average, dark respiration rates may have been suppressed by glyphosine application in L 62-96. Differences in dark respiration rates among leaf positions were also not statistically significant.

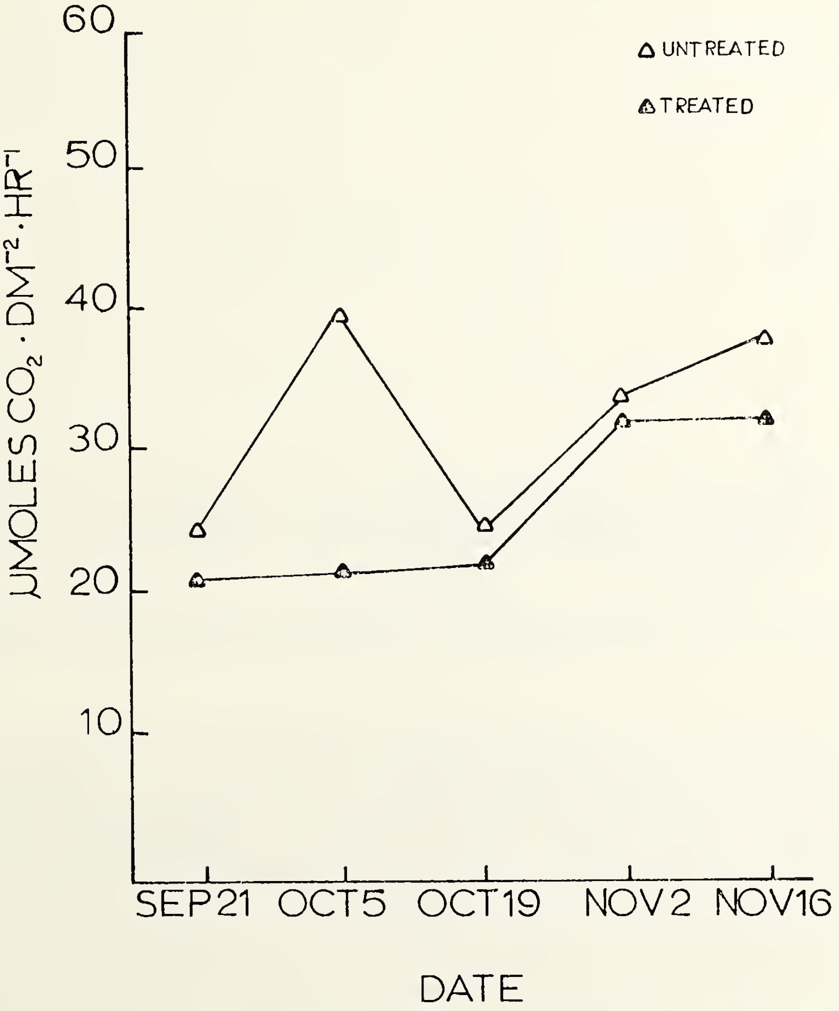

Fig. 2. Dark respiration rates of L 62-96 with and without glyphosine application as plotted across harvest dates.

Differences due to the leaf position source of variation for the yield component specific leaf weight were statistically significant $(> \underline{F}_{\alpha} = .01)$. Specific leaf weight appeared to increase as depth into the canopy increased. The harvest date source of variation was also observed statistically significant. Generally, Fig. 3 shows that specific leaf weight may have increased slightly in both treated and untreated L 62-96 across harvest dates. As depicted in Table 1, no effects of glyphosine application were observed for the treatment source of variation.

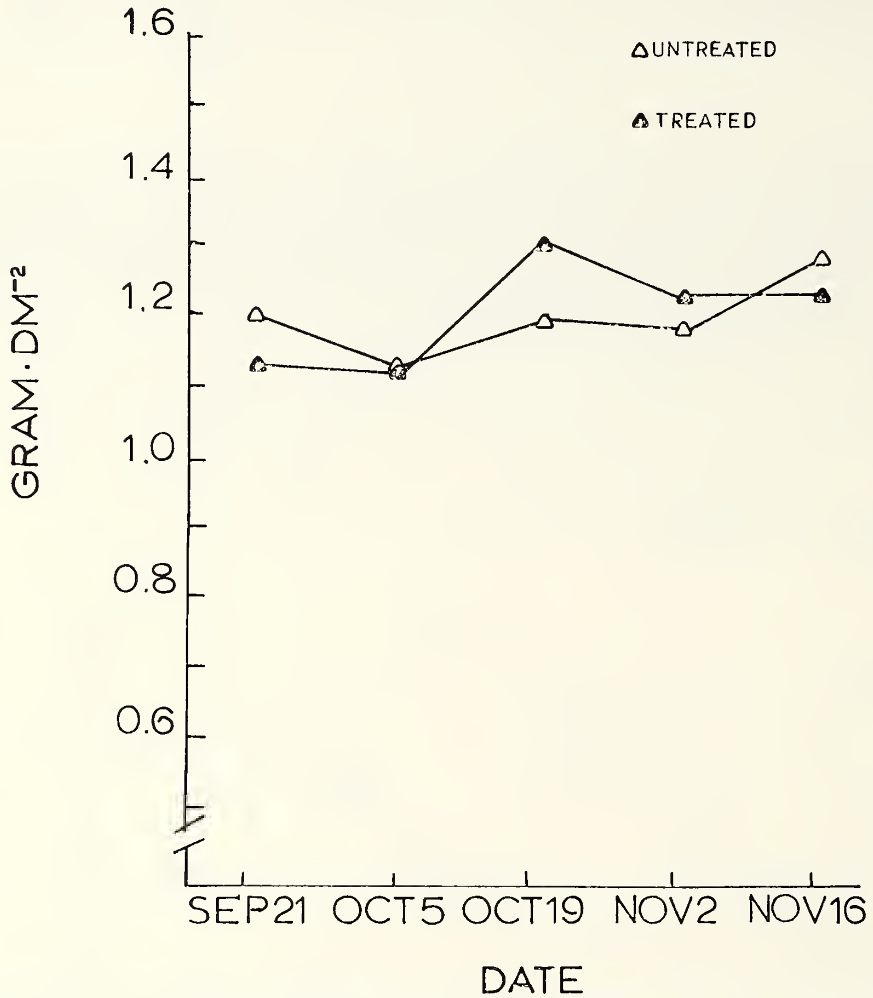

Fig. 3. Specific leaf weights of L 62-96 with and without glyphosine application as plotted across harvest dates.

Those differences in percent dry weight associated with leaf positions were statistically significant $(> \underline{F}_{\alpha} = .01)$. Generally, within both the treated and untreated L 62-96 a decrease was observed by leaf position as depth into the canopy increased (Table 2). Differences due to the harvest date and treatment by date source of variation were also statistically significant. Fig. 4 shows that although the glyphosine treatment did appear to have a higher percent dry weight in the initial stages of the experiment, these differences seemed to disappear during the latter stages of this study. Average percent dry weights for treated and untreated L 62-96 are shown in Table 1. These data were not significantly different but do suggest that the glyphosine treatment may have had a higher percent dry weight than its untreated counterpart.

Table 2. Percent dry weight values as averaged across harvest dates for L 62-96 treated with glyphosine and its untreated counterpart.

	Leaf position*				
Treatment	+1	+3	+5	+7	+9
Untreated	36.06	36.65	35.19	33.81	33.77
Treated	39.60	37.06	36.54	36.27	34.78

*Significant at .01 level.

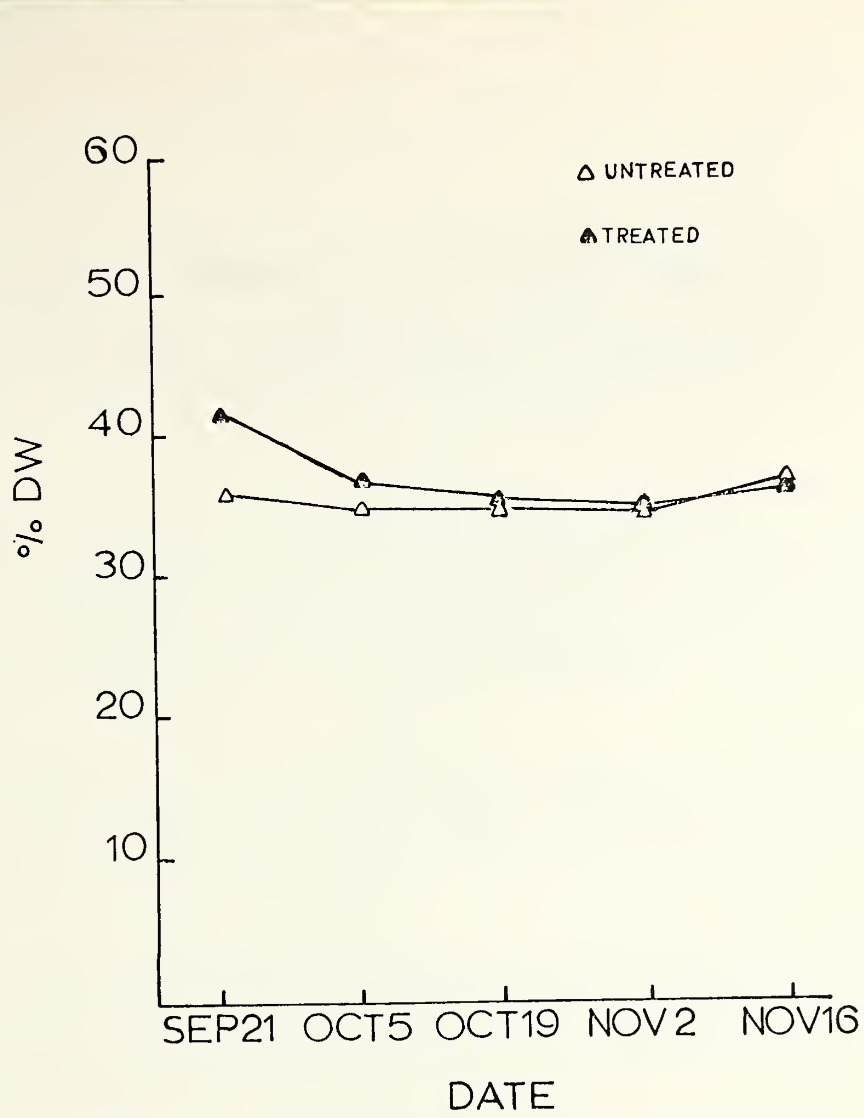

Fig. 4. Percent dry weights of L 62-96 with and without glyphosine application as plotted across harvest dates.

While treatment differences associated with all four physiological yield components were not statistically significant, differences in the leaf position source of variation for the variables specific leaf weight and percent dry weight were observed significant ($>F_{\alpha} = .01$). In the case of all variables, these differences associated with time (the harvest date source of variation) were statistically significant. These data indicate that the examination of ripeners on certain physiological components of sugar cane yield during the latter stages of crop development might be a useful tool in evaluating such compounds. Continued sampling during this period could also aid the physiologist in determining more accurately the effect of ripeners on the natural ripening process of the sugar cane plant.

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BASIC SUGARCANE BREEDING IN SUBTROPICAL LOUISIANA[1/]

P. H. Dunckelman and S. Nagatomi
U. S. Sugarcane Field Laboratory, ARS, USDA
Houma, Louisiana and
Tanegashima Branch, Kyushu Agricultural Experiment Station
Nishinoomote, Kagoshima, Japan

ABSTRACT

By manipulation of basic and established sugarcane breeding stocks under natural and artificial environments, it was possible to make crosses that would otherwise have been impossible at Houma. Outdoor racks, a photoperiod house, and a breeding greenhouse were used to obtain a suitable environment for flowering, crossing, and seed production. Seventy-three biparental crosses were made during the 1976-77 season for the purpose of combining the economic features of the commercial breeding stocks with the hardiness and disease resistance of Saccharum spontaneum L., the vigor of S. robustum Brandes and Jesw. ex Grassl, and the large size and juiciness of S. officinarum L.

INTRODUCTION

The Louisiana sugar industry must presently rely on the established sugarcane breeding lines for the production of improved varieties. Progress in breeding with these few basic lines has been steady, and should continue (4). However, hardier varieties with more complex genetic makeups are needed to better resist attacks by insect pests and diseases, to withstand more cold and drought, to simplify mechanization, to produce more and better stubble crops and to increase yields of sugar per acre (1, 2, 3, 6, 7).

Attainment of these objectives will be difficult and time consuming; however, our genetic base is being broadened and improved with each additional regimen of crossing, selection, and backcrossing. The introduction of new genetic factors (genes) from exotic germplasm into the established breeding base is a long-term process of planned introgression whereby the desired features of the new germplasm are gradually being combined with the old germplasm. It is anticipated that this process will lead to the production of improved sugarcane varieties for Louisiana and other mainland U. S. sugar producing areas (2). This paper reports the progress of the basic breeding program at the U. S. Sugarcane Field Laboratory, Houma, Louisiana, in 1976.

PARENTAL MATERIAL AND TECHNIQUE

In the fall of 1975, seed cane of 143 recommended parental varieties of sugarcane was collected from the nursery of basic breeding canes and from agronomy test fields. The parents chosen comprised 27 clones of the hardy wild species Saccharum spontaneum L.; 12 of the sweet, juicy, large barrel noble species S. officinarum L.; 24 of the adapted commercial-type interspecific hybrids; and 80 vigorous interspecific hybrids from new lines, including hybrids between the above-mentioned Saccharum species and S. robustum Brandes and Jesw. ex Grassl.

Healthy single-bud cuttings of each parental variety were planted upright in flats of sterilized soil in the seedling greenhouse. After the shoots became well established they were periodically clipped back to promote tillering and strong, stocky plants. In January 1976, when the plants were 3 months old, they were transplanted to 10-gallon galvanized steel cans placed on the floor and on the carts of the sugarcane-breeding greenhouse. The cans contained a mixture of 40% soil, 30% sand and 30% spagnum peat with 3 inches of course gravel in the bottom of each can. The crowns of the plants were set about 3 inches below soil level which facilitates the production of many tillers from buds beneath the soil surface.

When the weather warmed up in late March, 80 cans planted with noble canes were placed on the carts of the four photoperiod rooms. The 160 cans planted with wild canes and new F_1 and BC_1 hybrids from various lines of S. spontaneum, S. officinarum and S. robustum were moved to outdoor racks. An additional 120 cans planted with the above-mentioned categories of breeding material and with the commercial-type interspecific hybrids were left on the carts of the sugarcane breeding greenhouse. The carts were moved in and out of the greenhouse as weather conditions warranted.

For maintenance of an even growth rate, a complete liquid fertilizer (12-6-6 plus trace elements) was applied monthly between April 1 and July 1; each application per can approximated a per acre rate of 30 lb of N, 15 lb of P and 15 lb K plus traces of iron, copper, manganese, and zinc. For control of the sugarcane borer, Diatraea saccharalis F., the plants were sprayed seven times with a systemic insecticide

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[1/] A contribution from ARS, USDA in cooperation with the Louisiana Agricultural Experiment Station.

between April 11 and September 9. At intervals throughout the growing season, dry leaves and immature suckers were removed so that only the dominant, most uniform stalks remained. When the stools of cane became tall enough, they were tied upright to tie-bars to prevent the canes from lodging and the cans from being toppled by strong winds.

Photoperiod treatment of the noble canes was started on July 15. The 12 varieties in the test were subjected to a fixed daylength of 12 hr 25 min from July 15 to September 13 (69 days). The daylength was adjusted by varying the sunrise rather than the sunset time. The canes were moved outside into sunlight precisely at the specified time in the morning and back into the photoperiod house at or after sunset.

The early-flowering parent canes on the outdoor racks were exposed to natural conditions. Those on the carts of the breeding greenhouse were rolled indoors at sunset after September 8 to protect them from low night temperatures. At Houma (29° 35'N) the shortening daylengths from September 8 (12 hr 34 min) to October 15 (11 hr 28 min) provide the inductive photoperiod range for the flowering of sugarcane. The shortening of the daylength and the nighttime temperature control interact favorably to trigger the flowering response in many basic band commercial breeding stocks at this location.

Airlayering of the stalks of parent material was begun in September when the cane was nearly ready to flower. Airlayering consisted of enclosing two nodes of each stalk in soil or in sphagnum moss surrounded by black polyethylene film. By the end of October a total of 1500 stalks, including some of each parent cane, were airlayered. Each week the airlayers were irrigated by injection of water through the polyethylene film with a specially designed nozzle. The airlayering technique permits the development of above-ground roots in the three or four weeks just before crossing. When the airlayered stalks were moved into the greenhouse, the rooted portions were placed in concrete troughs filled with flowing water moved by a small electric-powered pump; apparently the biological processes of the individual stalks were virtually unimpaired.

All crosses were made in the isolation cubicles of the sugarcane breeding greenhouse. First, the male-fertile tassels of parent canes were affixed to tie-bars within the cubicles; male-sterile tassels were then tied in place beneath the male-fertile tassels. The tie-bars were tapped each morning during the fertilization period so that this vibration would cause pollination.

After cross-pollination, which was completed in nine to twelve days (depending upon varietal differences), the crosses were dismantled. The male-fertile tassels were discarded, and large paper bags were placed over the aggregated tassels of each male-sterile seed parent. About twenty days after bagging, the tassels were removed from the stalks and the bags were hung (upside down) in a drying cabinet for three days at a temperature of 105°F. After drying, the "fuzz" containing the true seeds was stripped from the rachises of the tassels. Germination was tested to estimate the number of viable true seeds per cross.

WEATHER AND FLOWERING

Despite the coldest weather since the start of the basic crossing program at Houma five years ago, enough tassels from desirable new and old germplasm were obtained from the can cultures in 1976 to continue crossing and recurrent selection in new genetic lines. During September the minimum night temperatures dropped below the critical 65 F level six times; temperatures below 65 F inhibit floral initiation in sugarcane. Throughout October and November the minimum night temperatures averaged 8.5 F and 10.5 F lower, respectively, than the averages for these months over the preceding five-year period.

Excellent flowering in both basic and commercial breeding stocks was obtained in can cultures kept on the carts of the tall sugarcane breeding greenhouse. Throughout September and October the carts were rolled indoors at night and outdoors in daytime. Night temperatures inside the greenhouse were controlled at about 70 F. After November 1, when daytime temperatures began to drop, the canes were moved outside only when the temperature reached 70 F or higher. This augmentation of the natural photoperiod, with artificial control of temperature, created a suitable environment for the induction of flowering in many variable sugarcane breeding stocks. Floral initiation, elongation, emergence of tassels, and finally flowering seemed to be normal. A good ratio of male-sterile to male-fertile tassels also was noted.

Varieties of S. spontaneum and early-generation (F_1 and BC_1) selections from new interspecific breeding lines were placed on outdoor racks because many such clones often flower early and profusely despite exposure to weather that inhibits floral initiation and flowering in the more highly bred commercial and noble sugarcanes. Although earlier observations of terminal growing points revealed that well-defined floral primordia were present in all but a very few varieties on outdoor racks, none of the 15 relatively late-flowering S. spontaneum varieties or the 80 F_1 and BC_1 new-line interspecific hybrids tasseled outdoors during the abnormally cool fall of 1976. However, in some of the hardier selections inflorescences developed to advanced "boot" stages outdoors and these tasseled when moved inside the greenhouse.

Of the 12 noble varieties subjected to fixed photoperiod of 12 hr 25 min for 69 days from July 15 through September 13, only one, Fiji 40, developed to the flag stage of flowering on the carts of the unheated photoperiod house. Previous studies (3) had indicated that a fixed photoperiod of 12 hr 25 min for 89 days was the best photoperiod regime for flowering of nobles; however, due to failure of the noble canes to reach the desired stage of growth in June of 1976, it was necessary to postpone the photoperiod treatment until July 15. When moved into the greenhouse, Fiji 40 produced healthy tassels. Six other nobles, including Bambu, NG 28-14, NG 51-52, NG 51-144, NG 51-146, and NG 51-163, set floral primordia under the fixed photoperiod treatment but failed to produce tassels when moved into the greenhouse. No well-defined floral primordia were seen upon examination of terminals in Lahaina, NG 28-2, NG 28-288, Otaheite, and Vellai. The failure of the nobles to flower in 1976 was probably due to the interaction between the late start of the photoperiod treatment and the early onset of cold weather. The latter retarded floral initiation and flowering in the early-flowering nobles on the photoperiod carts and prevented or reversed the initiation process in the late-flowering nobles on the carts of the unheated photoperiod rooms.

CROSSING AND TRUE SEED PRODUCTION

Crossing was begun on October 26 and continued until December 16. Seventy-three biparental crosses (Table 1) were made in the cubicles of the tall sugarcane breeding greenhouse. Every one of the crosses involved at least one basic breeding cane as the nonrecurrent parent. Recurrent parents consisted of commercial-type breeding canes and the noble cane Fiji 40. The complex of parent canes, comprising both basic and established breeding lines, included recommended varieties and special new-line selections with high sucrose, large diameter stalks, high stalk populations, low fiber, juiciness, excellence of type, vigor, and resistance to diseases, cold, and borers.

Table 1. Individual breeding lines under development at Houma, LA, in 1976.

New breeding line	Number of crosses	Estimated number of viable seeds
S. officinarum Fiji 40 X *S. spontaneum* US 56-15-2	1	1196
S. officinarum Fiji 40 X L 65-69	1	70
S. officinarum Fiji 40 X F_1 *S. spontaneum* SES 147 B	2	1240
S. officinarum Fiji 40 X F_1 *S. spontaneum* SES 205 A	1	2400
S. officinarum Fiji 40 X BC_1 *S. spontaneum* SES 92	1	770
F_1 *S. spontaneum* SES 189 X F_1 *S. spontaneum* SES 147 B	2	1125
F_1 *S. spontaneum* SES 189 X F_1 *S. spontaneum* SES 189	2	0
F_1 *S. spontaneum* SES 189 X F_1 *S. spontaneum* SES 205 A	5	14585
F_1 *S. spontaneum* SES 189 X F_1 *S. spontaneum* US 59-1-1	1	0
F_1 *S. spontaneum* SES 189 X BC_1 *S. spontaneum* Sumatra #2	1	0
F_1 *S. spontaneum* SES 189 X F_1 *S. robustum* NG 57-208	2	136
F_1 *S. spontaneum* SES 147 B X F_1 *S. robustum* NG 57-208	1	525
F_1 *S. spontaneum* US 56-15-8	2	8150
BC_1 *S. spontaneum* SES 124	1	0
BC_1 *S. spontaneum* SES 189	17	10690
BC_1 *S. spontaneum* SES 147 B	4	1760
BC_1 *S. spontaneum* SES 205 A	5	12044
BC_1 *S. spontaneum* Tainan (2n=96)	1	0
BC_1 *S. robustum* NG 57-208	3	4524
BC_1 *S. spontaneum* SES 147 B X F_1 *S. spontaneum* SES 189	1	0
BC_1 *S. spontaneum* US 56-14-4 X BC_1 *S. spontaneum* SES 147 A	1	1950
BC_2 *S. spontaneum* US 56-15-8	3	7075
BC_2 *S. spontaneum* Gehra Bon	4	15321
BC_2 *S. spontaneum* SES 2	1	250
BC_2 *S. spontaneum* SES 147 A	2	1970
BC_2 *S. spontaneum* SES 147 B	1	1000
BC_2 *S. spontaneum* US 56-14-4	4	11760
BC_3 *S. spontaneum* Pasoeroean	1	671
Ripidium X F_1 *S. spontaneum*	2	0
Totals	73	99212
Number seedlings from germination counts		4911
Grand total		104123

Whenever possible the combinations were made with specific objectives in mind and with a carefully planned choice of available flowering clones. An estimated 5,676 viable true seeds were produced from six crosses of *S. officinarum* clone Fiji 40 with *S. spontaneum* US 56-15-2 and L 65-69 and two F_1 and one BC_1 *S. spontaneum* selections. Over 18,000 seeds were produced in 16 intra- and interspecific crosses involving various F_1 and BC_1 selections from *S. spontaneum* and *S. robustum* lines. New F_1, BC_1, and BC_2 lines of *S. spontaneum* were advanced to the BC_1, BC_2, and BC_3 breeding levels, respectively, in 46 crosses that yielded in excess of 69,000 viable true seeds. Also, one BC_1 S. robustum line (NG 57-208) involving 3 crosses gave an estimated 4,524 viable true seeds. Over 6,000 additional viable true seeds were produced from miscellaneous exploratory crosses. Two intergeneric crosses, Ripidium X S. spontaneum, were unsuccessful; however, the Ripidium tassels were in very poor condition when the crosses were made.

Harvest of seeds was completed on January 20, 1977. Germination tests revealed that an estimated 104,123 viable true seeds were produced from the 73 crosses made during the 1976 sugarcane breeding season. All of the seed was turned over to the selection phase of the breeding program.

CONCLUSIONS

By manipulation of basic and established sugarcane breeding stocks under natural and artificial environments, it was possible to make crosses that would otherwise have been impossible at Houma.

One hundred and forty-three selected parent canes of widely differing genetic constitution were made available the crossing program by cooperating scientists. As a group, these canes contain the genetic factors thought to be essential for the breeding and development of improved sugarcane varieties adapted to subtropical conditions on the U. S. mainland.

The parent canes were grown until nearly ready to flower in can cultures under three sets of conditions designed to promote and synchronize the flowering of plants with different genetic makeup. Difficult-flowering noble canes were treated under an artificially-contrived photoperiod regimen. Commerical breeding canes and selected new-line interspecific hybrids were exposed to natural daylengths plus night temperature control. New early-generation S. spontaneum derivatives were placed on outdoor racks.

Because of abnormally cold weather after October 1, flowering was severely inhibited in parent canes exposed to the cold on outdoor racks and on carts of the unheated photoperiod rooms. The biological functions of floral initiation and elongation of primordial inflorescences were suspended by the cold, but many parent canes so affected could easily have been induced to flower if greenhouse space had been available. In contrast to the poor flowering of canes on outdoor racks and photoperiod carts, flowering was good in both basic and conventional parents on the carts of the sugarcane breeding greenhouse.

Although fewer crosses were made and fewer true seeds produced during 1976 than is usual at this location, there were enough of both to meet the seasonal requirements of the seedling phase of the basic breeding program at Houma. In all, 73 biparental crosses were made with airlayered (live-rooted) flowering stalks of recommended parent canes; only nine of these were unsuccessful. The 64 successful crosses resulted in the production of more than 100,000 viable true seeds, representing most of the lines thought to be necessary for upgrading sugarcane varieties for cultivation in a subtropical environment.

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A PROGRESS REPORT ON MECHANICALLY PLANTED SUGARCANE IN FLORIDA

B. R. Eiland and J. E. Clayton
Science and Education Administration
USDA
Belle Glade, Florida

ABSTRACT

Yields from three field experiments, planted over a 2-year interval, were determined for different planting methods in Florida. These planting methods were: 1) conventional wholestalk planting, 2) mechanically harvested seed material dropped by hand, and 3) mechanically harvested seed material dropped by a mechanical planter. Planting rates for mechanically planted seed were higher than those of other planting methods when adequate cane was applied. In one experiment, yields obtained from mechanically planted treatments were similar to those obtained using conventional wholestalk planting when planter skips were filled by hand using excess seed material in the furrow. The application of this technique with mechanical planting should provide comparable yields until mechanical planters achieve a higher performance level.

INTRODUCTION

Considerable interest in mechanical planters for Florida was generated in 1974 and 1975 when about 2,700 acres of cane were planted with experimental planters. Yields from these plantings were inconsistent during periods of high sugar prices and as a result, mechanical planters have not been used to plant significant additional acreage. Poor yields were attributed to numerous factors including poor seed material, mechanical harvester damage to the seed, mechanical planter damage, insect infestation, shallow covering, and delayed covering (1).

During initial mechanical planter development at the USDA Sugarcane Harvesting Research Unit, we recognized the need to compare yields from mechanical planting with other planting methods. Three preliminary experiments were planted over a 2-year interval using different planting methods to determine if mechanically planted cane could produce similar yields to cane planted by conventional methods.

MATERIALS AND METHODS

Exp. No. 1. The purpose of this experiment was to compare yields of three planting methods and to evaluate the performance of a mechanical planter. Cane was planted on a cooperator's farm beginning on March 4, 1975 and continued through March 8, 1975. Two varieties, Cl 54-336 and CP 56-59, were planted using three planting methods: conventional wholestalk planting (CW), mechanically harvested seed dropped by hand (MC-HD), and mechanically harvested seed planted by a mechanical planter (MC-MP). Each plot was 20 feet wide (4 rows) and 0.5 mile long. The stalk weight, stalk length, trash content, and internode length were determined from a 10-wholestalk sample of seed cane of each variety. The quantity of seed material used in the mechanically planted treatments and the hand-dropped treatments were weighed. The seedpiece length, number of eyes, number of damaged eyes, and the source of eye damage were determined on 30 seedpieces, selected randomly from furrows of each mechanically planted treatment.

The cane was hand-cut for yield determinations at an age of 8-1/2 months in November 1975. The cane was loaded onto conventional planting wagons using a grab loader. Each wagon was weighed on portable scales before entering the field and upon leaving the field. Treatment yields were calculated from the cane weights determined from the loaded wagons. An adjusted yield, because of covering delays, was calculated using average yield reductions from covering delays in other experiments (2).

Exp. No. 2. The purpose of this experiment was to compare planting rates, dates of planting and yields for three planting methods. Seed cane, variety Cl 59-172, was planted in late October and early November, 1975. A 3-acre field was mechanically planted except for a 3-row treatment using conventional wholestalk planting and a 3-row treatment using mechanically harvested seed dropped by hand. Three treatments consisting of 3 rows each were selected from the mechanically planted field. The three mechanically planted treatments included a plot planted about 10 days earlier than the remainder of the field and two plots planted at the same time as the conventional planting. As a result of using different planting equipment, row widths were not consistent. The quantity of seed material used for hand-dropped planting, conventional planting, and mechanical planting was weighed. Planting rates were calculated from treatment row lengths. A random sample of 10 wholestalks was cut, weighed, and measured for length to determine a theoretical planting rate for two continuous lines of cane. Skips, 2 feet and longer, left by the mechanical planter were counted and measured in 16 rows to determine the percent skips in the row. An insecticide to control wireworms was applied before the cane was covered. Several months after germination, 9 rows were measured for skips after emergence.

The cane was harvested mechanically at an age of about 15 months in mid-January 1977. Yield per acre and yield per foot of row were calculated from the treatment area and row length.

Exp. No. 3. The purpose of this experiment was to compare yields of two methods of mechanical planting with one conventional wholestalk planting. Approximately 1.3 acres of variety Cl 41-223 were planted using the conventional wholestalk planting with an adjacent block of 1.3 acres planted mechanically. Two methods of mechanical planting--normal mechanical planting without planter skips filled and mechanical planting with skips filled--were used in the mechanically planted block. Every other row in the mechanically planted block was planted initially. Planter skips were filled by field walkers from excess seed material in the furrow. These rows were covered and the remaining rows were planted mechanically without eliminating planter skips. An insecticide to control wireworms was applied before the cane was covered. Rows were 5 feet apart and 572 feet long.

The cane was killed by a freeze when about 9 months old. Individual cane rows were mechanically harvested and weighed for yield determinations when the cane was about 11 months old.

RESULTS

Exp. No. 1. Physical characteristics of the two varieties used for seed cane are shown in Table 1. The stalks for both varieties were about 10 feet long and weighed under 4 lb each. The theoretical planting rate for each variety was about 3 tons per acre. A large difference in trash content was found between the two varieties. This difference had a serious effect on the mechanical planter performance.

Table 1. Physical characteristics of two sugarcane varieties used in Exp. No. 1.

	Variety Cl 54-336	Variety CP 56-59
Avg. stalk length, ft	10.9	9.2
Avg. stalk weight, lb	3.8	3.9
Theoretical planting rate, lb/A, (2 continuous lines)	6070	7390
Trash content, %	10.0	24.0
Average internode length, in.	5.7	3.9
Undamaged mechanically planted eyes, %	46.0	87.0
Undamaged mechanically planted eyes per acre	16,900	46,600
Avg. mechanically-harvested seedpiece length, in.	19.3	20.2

The average internode length of Cl 54-336 was longer than the internode length of CP 56-59. More cane would be required for Cl 54-336 than for CP 56-59 to obtain a similar number of eyes per acre. Measurements of the seedpieces planted by the mechanical planter revealed that Cl 54-336 had an unusual number of missing eyes. We observed some damage to the seedpieces by birds before the cane was cut. Harvester and planter mechanisms were responsible for damaging less than 10% of the eyes in each variety. In the case of Cl 54-336, over 50% of the eyes were missing. The cane was mechanically harvested from an outside row that was used by birds for roosting at night. Damage on the inside rows of the field seemed to be much less. A large difference in the number of viable eyes planted per acre resulted between varieties because of the eye damage. The average length of the mechanically planted seedpieces was approximately the same for both varieties.

The skips left by the mechanical planter and the hand-droppers are shown in Table 2. The hand-droppers did not leave any skips, 2 feet or longer, while the mechanical planter left a substantial amount of row length without cane. Variety CP 56-59 had about 50% more skips than Cl 54-336 because it was difficult to meter with its higher trash content. Both varieties had similar average skip lengths. No skip measurements were taken on the conventional wholestalk planting but skips were assumed to be zero.

Application rates of seed material for each variety are shown in Table 3. The mechanically planted Cl 540336 had an application rate 10% higher than the hand-dropped rate. The mechanically planted CP 56-59 had considerably lower application rate than the hand-dropped rate because excessive trash in the seed material interferred with metering. The excessive trash resulted from poor cleaning because a belt drive failed on a harvester cleaning device while harvesting CP 56-59.

Based on yields in Exp. No. 1, cane from conventional wholestalk planting out-yielded the cane from the other planting methods for both varieties. A number of problems occurred after the start of planting ranging from equipment breakdowns to covering delays. An initial 2-day effort ended up as 5 days. The delay in covering of the earlier plantings obviously reduced yields. From other experiments with varying weather conditions, a minimum of 5 percent reduction in yield per day of covering delay can be assumed in evaluating yields (2, unpublished data). The yield of the mechanically planted Cl 54-336 was similar to the yield of the hand-dropped cane but was lower than yield of the conventional wholestalk-planted cane when adjusted for covering delays. For CP 56-59, the yield of the hand-dropped cane was similar to the yield of the conventional wholestalk-planted cane. The yield of the mechanically planted cane adjusted for covering delays, was lower than the yields from the other 2 planting methods. Mechanically planted treatments were not covered as deeply as the conventionally planted treatments because the beds were compacted by the mechanical planter and this may have contributed to the lower yield of the mechanically planted treatments.

Table 2. Comparison of characteristics of the mechanical planter skips with hand-dropped skips.

Plot description	Number of skips*	Total skip length (ft)	Avg. skip length (ft)	Percent skips
		Variety Cl 54-336		
MC-HD	0	0	--	--
MC-MP	360	2021	5.61	19.0
CW	No measurements - assume 0 skips			
		Variety CP 56-59		
MC-HD	0	0	--	--
MC-MP	532	3134	5.89	30.0
CW	No measurements - assume 0 skips			

*Skips were considered as any row length, 2 feet or longer, without seed material.
CW - Conventional Wholestalk Planting
MC - Mechanically-Cut (seedpieces up to 24 inches long)
MP - Mechanically-Planted
HD - Hand-Dropped

Table 3. Application rates, gross cane yields, and adjusted cane yields for covering delays for three planting methods with two varieties.

Plot description	Application rate (lb/acre)	Yield (tons/acre)	Adjusted yield for covering delays
		Variety Cl 54-336	
MC-HD 3-day covering delay	5440	20.9	24.6
MC-MP 4-day covering delay	6240	20.2	25.3
CW No covering delay	No measurement	28.8	28.8
		Variety CP 56-59	
MC-HD 2-day covering delay	7270	29.8	33.1
MC-MP 2-day covering delay	4830	24.4	27.1
CW No covering delay	No measurement	33.3	33.3

MC - Mechanically-Cut
MP - Mechanically-Planted
HD - Hand-Dropped
CW - Conventional Wholestalk Planting

Exp. No. 2. A theoretical application rate for two continuous lines of cane was determined from a 10-stalk sample to be 0.97 lb per foot of row. The mechanical planting had the highest application rate of 1.09 pounds of seed cane per foot (Table 4). Conventional wholestalk planting had the lowest application rate of 0.90 lb of seed cane per foot of row. The percent skips in 16 rows planted mechanically averaged 6% before covering which is approaching an acceptable level. Skip measurements from 9 of the 16 rows taken several months after germination showed 35% skips when using the same skip criteria. This difference tends to override the planter's performance.

Table 4. Application rates of seed cane and percent skips for three planting methods.[1]

Planting method	Planting rate (lb/ft)	Percent skips
CW	0.90	*
MC-HD	0.94	*
MC-MP	1.09	6.0[2]
Theoretical Application Rate	0.97	

[1] Variety Cl 59-172
[2] Skips totaled 35% after emergence
* Skips assumed to be zero
MC - Mechanically-Cut
MP - Mechanically-Planted
HD - Hand-Dropped
CW - Conventional Wholestalk Planting

Cane yields of the five treatments are shown in Table 5. Yields are shown by two methods because of the different row spacing in the treatments. The highest yield per acre was in the late October mechanical planting, and the highest yield per unit row length was in the conventional wholestalk planting. The October planting germinated much faster and with subsequent growth had a much earlier canopy closure than the other treatments. The large difference in yield between the hand-dropped cane and the conventional wholestalk planting is not readily understood because initial stands appeared similar. A treatment of the mechanically planted cane (Plot 5) was similar in yield to the conventional wholestalk planting and the other mechanically planted treatment (Plot 4) was lower. Yields on a unit row length basis differed considerably between the two mechanically planted treatments indicating that row spacing probably influenced yield.

Table 5. Plot description, row width, plot area, and yield for three planting methods using variety Cl 59-172.

Plot No.	Plot description & planting date	Row width (ft)	Plot area (ft2)	Yield (T/A)	Yield (lb/ft)
1	MC-HP Oct. 23, 1977	5.5	7788	46.1	11.65
2*	MC-HD Nov. 3, 1977	6.5	10013	34.7	10.49
3*	CW Nov. 3, 1977	6.5	10369	40.7	12.30
4*	MC-MP Nov. 3, 1977	5.5	8943	37.2	9.40
5	NC-MP Nov. 4, 1977	6.3	10640	41.4	12.05

*Planting rates measured.
MC-MP - Mechanically-Cut, Machine Planted
MC-HD - Mechanically-Cut, Hand-Dropped
CW - Conventional Wholestalk

Exp. No. 3. Stands of cane obtained from the mechanically planted rows with skips filled were more uniform than those where skips were not filled. Yields of the mechanically planted rows with skips filled were equal to those from conventional wholestalk planting (Table 6). Yields from the mechanically planted rows without skips filled were considerably lower than yields from the conventional planting method.

Table 6. Individual row yields (T/A) using variety Cl 41-223 for conventional wholestalk planting, mechanical planting without skips filled and mechanical planting with skips filled by field walkers.

Conventional wholestalk planting	Mechanical planting without skips filled	Mechanical planting with skips filled
40.4	31.4	41.3
48.7	30.1	38.5
41.5	21.3	45.2
42.0	22.7	39.7
40.4	23.8	44.4
	22.5	45.8
	19.2	42.8
	28.6	
Avg. 42.6	Avg. 24.9**	Avg. 42.5 NS

**Mean is significantly different from the mean of the conventional wholestalk planting using a t-test at the .01 level.

NS Mean is not significantly different from the mean of the wholestalk planting using a t-test.

DISCUSSION

Exp. No. 1. The logistics required exceeded our experimental capabilities for this large experiment. A significant improvement in the mechanical planter's performance was necessary before further testing. Using the covering delay effects, yields equal to conventional wholestalk planting may be obtained with mechanically harvested seed dropped by hand if good planting practices are followed.

Exp. No. 2. Yields of mechanically planted cane were similar to yields of conventional wholestalk planting. Unfortunately, higher planting rates with mechanical planting appear necessary when compared to conventional wholestalk planting.

Exp. No. 3. Filling in skips behind mechanical planters is certainly justified with the current performance level of mechanical planters. It appears that yields equal to conventional wholestalk planting can be obtained using this method.

Successful mechanical planting with current experimental planters, coupled with mechanical harvesting of the seed material, requires total planning from seed selection to covering. The varieties selected for planting should not have large bulging eyes that are easily damaged. The cane should be young and growing with viable eyes. The cane should be easily cut by the mechanical harvester without chokages and should be cleaned satisfactorily by the harvester. Seedpieces up to 24 in. long should be cut with the harvester. Field walkers should be used behind the planter to fill in skips by redistributing cane. The cane should be covered the same day as dropped with insecticides applied if necessary.

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VARIETAL DIFFERENCES IN SUGAR LOSSES WITH TWO HARVESTING SYSTEMS

B. R. Eiland, J. D. Miller, and G. J. Gascho[1]

ABSTRACT

Sugar losses in four sugarcane varieties after harvesting were measured for two harvesting systems--the wholestalk, hand-cut system and the mechanical chopper-harvester system. Sugar losses were determined on cane samples 1, 2, and 5 days after harvesting. Wholestalk samples did not have appreciable sugar losses up to 5 days after harvesting. Sugar loss rates in the mechanically harvested samples ranged from 3.2% per day for variety CP 68-1067 to 6.0% per day for variety CP 65-357. Sucrose, purity, sugar per ton, and pH all decreased in the mechanically harvested samples as the time after harvest increased. Changes in these juice characteristics were much larger for the mechanically harvested samples than for the wholestalk samples.

INTRODUCTION

The harvesting of sugarcane with mechanical harvesters has increased from 2% of the Florida sugarcane crop to about 30% over the last six harvesting seasons. Previously, all sugarcane was hand-cut and piled on the ground as complete stalks pending loading and transport for processing into sugar. Mechanically harvested sugarcane is chopped into short lengths as it is harvested and it begins to deteriorate much faster than does hand-cut, wholestalk cane as shown by Wood (13) and Gascho, Clayton and Gentry (5). Leuconostoc mesenteroides is the primary causal organism in the deterioration of chopped cane (4). Deterioration is considered any change in juice composition that occurs after the cane is subjected to any harvesting operation.

DeStefano (3) reported post-harvest losses of 5.2% of the recoverable sugar when burned, hand-cut, wholestalk samples were stored in the field for 4 days. Post-harvest deterioration in sugarcane was shown by Turner (11) and Lingerfelt, Ellis, and Arceneaux (7) to be variety dependent. Our study was conducted to compare sugar losses after harvesting in four new sugarcane varieties after they were harvested by the wholestalk, hand-cut harvesting system or by the mechanical chopper-harvester system.

MATERIALS AND METHODS

Four sugarcane varieties (CP 63-306, CP 63-588, CP 65-357, and CP 68-1067) were used in the experiment. The cane was first ratoon and about 12 months old. It was burned approximately 15 hours before harvesting began. We randomly selected 150 stalks of each variety along a row, cutting and topping them by hand. Chopped samples of each variety, containing 275 kg, were cut with a Toft 300[2] mechanical harvester which delivered the cane into citrus tubs. The mechanical harvester did not top the cane stalks uniformly because the cane was lodged. Wholestalk, hand-cut samples were stored adjacent to the citrus tubs in small bundles on the ground in the harvested field. This experiment was conducted and analyzed as a three-factor (time after harvest, harvest method, and variety) factorial with three replications.

Samples were milled with a hydraulically loaded, three-roller mill with a top roll pressure of about 700 kg/cm^2. Unavoidably, initial samples of variety CP 63-306 were milled 6 hours after harvest while initial samples of the other varieties were milled about 24 hours after harvest because of a harvesting delay. We measured brix of the cane juice with an automatic refractometer and polarity with an automatic polarimeter. The percent sucrose of the juice was calculated by Schmitz' Table (9). We calculated theoretical sugar yield of the samples by Arceneaux's modification of the Winter-Carp-Geerlig formula (2). Changes in cane weights because of dehydration were not measured and were not considered in sugar yield calculations.

The pol of three chopped samples could not be determined on day 5 because of severe deterioration. Therefore, missing data were determined by using the mean purity value for each treatment. Cane juice samples were then frozen and stored for about 4 months at -12 C or lower. One week prior to analysis of the stored samples, the temperature of the chamber was raised to -1 C. Juice samples were thawed and rapidly brought to 20 C by being placed in hot water. Samples were then analyzed for pH, titratable acidity (expressed as the number of ml of 0.1N NaOH required to raise the pH of 10 ml of juice to 8.4), and dextran (measured by the haze method) (8).

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[1] B. R. Eiland, Science and Education Administration, USDA, Belle Glade, FL; J. D. Miller, Science and Education Administration, USDA, Canal Point, FL; and G. J. Gascho, University of Florida, Agricultural Research and Education Center, Belle Glade, FL.

[2] Manufactured by Toft Bros. (Australia). Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by USDA or an endorsement by the Department over other products not mentioned.

Main-effect means for the three-factor factorial were calculated for each juice characteristic and were tested for differences by Duncan's Multiple Range Test (10). Sample changes on day 5 from day 1 mean values were determined for samples of each variety and harvest system. Mean changes were tested for variety differences by Duncan's Multiple Range Test.

RESULTS

The brix, percent sucrose in the juice, and theoretical sugar yield did not change from day 1 to day 2 (Table 1). Changes in purity, pH, and titratable acidity between day 1 and day 2 indicated deterioration had already begun. On day 5 all juice characteristics differed from day 2 values. Brix increased an average of 0.25 degrees per day, probably because of stalk dehydration. Weight-loss rates ranging from 1.0 to 1.5% per day have been reported for harvested cane (1, 7, 12). Percent sucrose in the juice decreased about 0.25 percentage points per day and purity decreased about 2.47 percentage points per day. These losses produced a sugar yield loss of 3.18 kg per ton of cane per day, neglecting losses because of cane weight decreases or milling changes.

Table 1. Main-effect means of three-factor factorial analysis for six characteristics of sugarcane juice.*

	Brix (°)	Sucrose (%)	Purity (%)	Sugar yield (kg/t)	pH	Titratable** acidity
Time After Harvest[1/]						
Day 1	18.93 A	17.54 B	93.05 C	125.81 B	4.96 C	2.18 A
Day 2	19.05 A	17.41 B	91.30 B	123.49 B	4.63 B	2.48 B
Day 5	19.93 B	16.54 A	83.19 A	113.10 A	4.43 A	3.10 C
Harvest Method[2/]						
Chopped	19.07 A	16.43 A	86.37 A	113.46 A	4.43 A	3.09 B
Wholestalk	19.53 B	17.89 B	91.99 B	128.14 B	4.91 B	2.08 A
Variety[3/]						
CP 63-306	18.15 A	15.84 A	88.04 A	111.29 A	4.88 C	2.40 A
CP 63-588	19.27 C	17.40 C	90.34 B	123.97 B	4.45 A	2.68 AB
CP 65-357	21.12 D	18.43 D	87.35 A	123.24 B	4.75 B	2.85 B
CP 68-1067	18.67 B	16.99 B	91.00 B	124.69 B	4.62 B	2.40 A

*Within a column factor, means followed by a different letter are significantly different at the 0.05 level according to Duncan's Multiple Range Test.

**The number of ml of 0.1N NaOH required to increase the ph of 10 ml of cane juice to 8.4.

[1/] Each value represents the average of 24 values.

[2/] Each harvest method value represents the average of 36 values.

[3/] Each variety value represents the average of 18 values.

All juice characteristics were affected by harvest method. Juice quality was lower for chopped samples than for wholestalk samples; this indicated that deterioration effects were more pronounced in the shorter cane pieces (Table 1). The percent sucrose in the juice was 1.46 percentage points lower in the chopped samples.

Variation in juice characteristics, attributable to variety differences, were evident. Brix and percent sucrose of the juice were highest in variety CP 65-357 and lowest for CP 63-306 (Table 1). Purity was higher in varieties CP 63-588 and CP 68-1067 than in varieties CP 63-306 and CP 65-357. Theoretical sugar yield was lower in CP 63-306 than in the other varieties. Titratable acidity and juice pH measurements were lower than those expected in fresh cane juice but values appeared relative between sampling dates and harvest method. The pH of the juice was highest in CP 65-357 than for CP 63-306 or CP 68-1067.

Extremely high dextran values were found in the juice samples which had been frozen. Apparently dextran or other substances precipitated by use of the haze method of analysis were formed under frozen storage conditions (6, 13). Normal freezing of raw juice samples is not recommended when dextran analysis by the haze method is desired at a later date.

The juice characteristics of each harvesting method of day 1 showed that wholestalk cane had slightly better juice qualities than the chopped cane (Table 2). Changes in mean values of juice characteristics between day 1 and day 5 are shown in Table 3 for each variety and harvesting method. Chopped samples showed considerable differences among varieties in all characteristics (Table 3). Wholestalk samples did not show any changes among varieties except in pH. Chopped samples of variety CP 65-357 showed the highest brix increase while variety CP 63-588 was the only sample to show a brix decrease. Wholestalk samples had an average brix increase of 1.38°. Percent sucrose of the juice in chopped samples of variety CP 68-1067 had the smallest loss of the varieties tested. Wholestalk samples showed small changes in percent sucrose in the juice over the test period. Of the chopped samples, the purity drop of variety CP 68-1067 was the smallest of the varieties tested. Purity drops for wholestalk samples were similar for all varieties and averaged 5.0 percentage points over the test period. Wholestalk samples did not show reductions in sugar yield over the test period while a considerable loss of about 25 kg/t occurred in the chopped samples. Chopped samples of variety CP 68-1067 had a sugar loss of about 15.63 kg/t which was about half the amount of loss of the other varieties. The sugar loss rate was 3.2% per day for variety CP 68-1067 and 6.0% per day for variety CP 65-357. The pH of chopped samples decreased more between day 1 and day 5 than did that of the wholestalk samples, thus indicating more microbiological activity in the chopped samples. Chopped samples of variety CP 63-306 had the largest pH decrease and variety CP 68-1067 had the smallest. The pH drops in wholestalk samples between day 1 and day 5 also differed with variety CP 63-588 having the smallest pH decrease and variety CP 68-1067 having the largest. The pH change appears to be inversely related to the initial juice pH for each harvest method, indicating that lower initial pH may retard sugar loss rates by preventing microbiological activity.

Table 2. Juice characteristics of four sugarcane varieties at day 1 after harvest for two harvest methods.*

Variety	Brix (°)	Sucrose (%)	Purity (%)	Sugar yield (kg/t)	pH
		Chopped Samples			
CP 63-306	17.49	15.88	90.84	113.47	5.23
CP 63-588	19.20	17.96	93.55	130.11	4.66
CP 65-357	20.21	18.75	92.85	129.94	4.72
CP 68-1067	18.17	16.74	92.17	122.87	4.42
		Wholestalk Samples			
CP 63-306	18.14	16.36	93.24	116.50	5.33
CP 63-588	18.46	17.22	93.34	124.65	4.72
CP 65-357	21.00	19.47	92.74	134.89	5.20
CP 68-1067	18.78	17.96	95.66	134.03	5.38

*Each value represents the average of three values.

Table 3. Changes in juice characteristics on day 5 from day 1 mean values of four sugarcane varieties for two harvest methods.*

Variety	Brix (°)	Sucrose (%)	Purity (%)	Sugar yield (kg/t)	pH
		Chopped Samples			
CP 63-306	0.81 B	-2.27 B	-16.42 BC	-26.42 B	-0.93 C
CP 63-588	-1.77 C	-2.39 B	-13.77 B	-26.17 B	-0.63 AB
CP 65-357	1.73 A	-2.59 B	-19.21 C	-31.41 B	-0.73 BC
CP 68-1067	0.41 B	-1.33 A	- 9.22 A	-15.63 A	-0.49 A
		Wholestalk Samples			
CP 63-306	1.07 A	-0.30 A	-5.48 A	1.41 A	-0.50 BC
CP 63-588	1.31 A	-0.54 A	-3.50 A	1.57 A	-0.08 A
CP 65-357	1.50 A	-0.47 A	-6.34 A	-4.94 A	-0.18 AB
CP 68-1067	1.62 A	-0.19 A	-4.87 A	-0.05 A	-0.64 C

*Each value represents the average of three values.
**Within a column, means followed by a different letter are significantly different at the 0.05 level according to Duncan's Multiple Range Test.

Changes in titratable acidity values (data not shown) showed no variety differences for either wholestalk or chopped samples. The chopped samples had considerably greater changes in titratable acidity than the wholestalk samples. These data indicated that within each harvest method, changes in titratable acidity may provide an indicator of cane juice quality.

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COMPARING SUGARCANE YIELD DATA FROM TWO GEOGRAPHIC AREAS ON LIGHT AND HEAVY SOILS[1]

H. P. Fanguy
U. S. Sugar Cane Field Laboratory
Agricultural Research Service, USDA
Houma, Louisiana
and
C. A. Richard
Sugar Station
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

ABSTRACT

Correlation coefficients were calculated on 1975 out-field results to determine the varietal response association between the two major sugarcane-growing areas of Louisiana. Positive correlations, significant at the 0.05 and 0.01 levels of probability, were found between varietal yields from the Mississippi River-Bayou Lafourche area and the Bayou Teche area. Nonsignificant "r" values were found for varietal yields between light and heavy soils. These results suggest that, while general variety recommendations should be made for the two geographic areas, different recommendations are required for light and heavy soils.

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[1] Only the Abstract of the paper was available for the Proceedings.

COMPARATIVE POST-FREEZE DETERIORATION OF SIX SUGARCANE VARIETIES[1]

G. J. Gascho
University of Florida
Agricultural Research and Education Center
Belle Glade, Florida
and
J. D. Miller
Agricultural Research Service, USDA
Canal Point, Florida

ABSTRACT

Deterioration rates of six sugarcane varieties were compared during a nine-week period following severe freezes at Belle Glade, Florida, January 18 to 20, 1977. Samples of CP 57-603, CP 68-1015, CP 65-357, CP 68-1076, Cl 41-223 and CP 63-588 were harvested each week. The data included measurements of brix, raw juice pH, acidity, stalk weight and juice per stalk. The theoretical yield of sugar per ton of cane, percent juice sucrose, percent purity and percent extraction were obtained by standard calculations. All varieties deteriorated badly over the nine-week period. The average loss in theoretical sugar yield was 26 lb of sugar per ton of cane per week. The rate of deterioration for the nine-week period, as guaged by the data collected, was lowest for CP 65-357. During the first five weeks following the freezes, theoretical yield and purity were the highest for CP 63-588, but, during the final weeks of the experiment, juice quality was highest for CP 65-357.

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[1] Only the Abstract of the paper was available for the Proceedings.

INFLUENCE OF PREHARVEST BURN INTENSITY ON CANE QUALITY

D. G. Holder and R. P. DeStefano
United States Sugar Corporation
Clewiston, FL 33440

ABSTRACT

The effect of cool burning versus hot burning cane at harvest was studied at United States Sugar Corporation. The mill juice from cool-burned cane had higher brix and sucrose than that from hot-burned cane. The percent yield of sugar was 5% greater in the cool-burned cane than in the hot-burned cane.

INTRODUCTION

It is important to minimize losses of the original sugar present in the standing unburned cane during the harvesting and milling process. In Florida and many other areas it is necessary to burn cane before harvesting to remove trash. DeStefano showed that preharvest burning accelerates the deterioration process markedly under Florida conditions (1). It would appear logical that the more intense the burn at preharvest the more rapid the deterioration rate. In order to test this hypothesis, the effect of burn intensity was studied on a commercial scale under two sets of conditions.

EXPERIMENTAL PROCEDURE

The first test was a study of the effects of burning cane for harvest in the early morning versus in the late afternoon. In the early morning, the lower ambient temperatures and dew deposits on the cane should lower the temperatures to which the stalks are subjected when cane is burned. In the afternoon when temperatures are higher and the cane and trash are dry, higher temperatures are generated which could cause more damage to cane stalks. A 4.2 acre field of Cl 47-83, and easily detrashing variety with non-clinging leaf sheaths, was divided into two sections for the test in March 1962 (2). There had been no frost on the standing cane. The afternoon burn was on day 1 at 4:30 pm Eastern Standard Time (EST) and the morning burn was at 7:00 am the following morning (day 2). Both sections were hand harvested on day 2. On day 3 the cane was loaded with a continuous loader (stalks are cut into billets by the continuous loader), transported to the mill, and processed. Five rail cars of each treatment were milled and the juice was sampled at the mill laboratory after each car. The data were analyzed in a completely random design.

The second test was a study of the effects of hot burning vs cool burning following the freezes of January 1977. The freeze killed all the terminals, lateral buds, and foliage in the test field of Cl 59-1052. The leaves and trash were very dry when the test was conducted at four weeks following the first freeze. The field was divided into two blocks of 18.5 acres each. The hot-burn area was completely burned in 5 min from 8:00 to 8:05 am EST on day 1. The rapid burn was accomplished by burning with the wind which was about 6 mph. The flames were 30 to 40 feet high and the heat was intense, with all the tops and all the leaf sheaths being burned off the cane. The area for cool burn was burned against the wind. The flames rarely leaped higher than the cane tops. Most tops and numerous leaf sheaths remained on the stalks. The burn took four hours, i.e. 8:15 am to 12:15 pm EST on the same date as the hot burn.

Again, the cane was harvested and milled commercially. On day 2 all cane was hand cut with the stalks topped about 20 inches from the terminal due to deterioration caused by the freeze. The cane was left on the ground during day 3. On day 4 the cane was loaded with a continuous loader and transported to the mill. There was no rain between burning and milling of the cane. All cane from the test field was milled consecutively about 80 hours after burning with that from the hot burn area milled first. Twenty-six cars were milled from each area. The mill juice was sampled four times from each area, each sample following a minimum of six cars of cane. The data were analyzed in a completely random design.

Theoretical sugar yields in these studies were calculated according to the formula,

$$\%\text{ yield } 96^{\circ}\text{ sugar} = Sx - By$$

which is based on the work of Arceneaux (3) and modified by Bourne (4), where S is percent sucrose in crusher juice and B is brix of crusher juice. Sucrose and brix reduction factors (x and y, respectively) required by this treatment were based on the average mill performance data for the previous five years.

RESULTS AND DISCUSSION

In the test of early morning burn versus late afternoon burn, the cane from the afternoon burn was more blackened and scorched than that from the morning burn. In the morning burned cane the crusher juice brix and sucrose were significantly higher, and the percent yield of 96° sugar averaged 0.60 points (5.18%) higher (Table 1); thus, the cane burned early in the morning was of better quality when it was milled. There were 106 and 112 tons of cane milled from the morning and evening burns, respectively.

Table 1. Comparison of mill juice data from sugarcane (Cl 47-83) burned early in the morning and late in the afternoon[1].

Factor measured	Type burn: Early morning	Type burn: Late afternoon	Significance[2]
Crusher juice			
Brix(°)	21.20	20.29	*
Sucrose(%)	18.30	17.54	*
Purity(%)	86.34	86.42	ns
Yield of 96° sugar(%)	12.17	11.57	ns

[1] Test conducted in March 1962; mill laboratory results.

[2] *, ns Rows significantly different at the 5% probability level and not significantly different, respectively.

Assuming equal production of 40 tons cane per acre, the morning burned cane would have yielded 9,736 pounds sugar per acre in comparison to 9,256 pounds sugar per acre for the afternoon burn for an advantage of 480 pounds sugar per acre for the morning burn.

In the second test the cool-burned cane was of higher quality at the mill than the hot-burned cane (Table 2). In the crusher juice cool-burned cane produced a highly significant improvement in brix and percent sucrose over the hot-burned cane. The percent yield of 96° sugar was 0.57 points (5.37%) higher in the cool-burned cane which was highly significant. Titratable acidity (5) was also lower in the cool-burned cane. There were 715 and 724 tons of cane from the cool-burned and hot-burned areas, respectively.

Table 2. Comparison of mill juice data from hot-burned and cool-burned sugarcane, Cl 59-1052[1].

Factor measured	Type burn: Cool	Type burn: Hot	Significance[2]
Crusher juice			
Brix(°)	19.04	18.08	**
Sucrose(%)	16.41	15.61	**
Purity(%)	86.20	86.36	ns
Titratable acidity	1.60	2.10	**
Yield of 96° sugar(%)	11.18	10.61	**

[1] Test conducted in February 1977; mill laboratory results.

[2] **, ns rows significantly different at the 1% probability level and not significantly different, respectively.

Assuming equal production of 40 tons cane per acre, the cool-burned cane would have yielded 8,944 pounds sugar per acre in comparison to 8,488 pounds sugar per acre for the hot burn for an advantage of 456 pounds sugar per acre for the cool burned cane.

The data from these studies show that the hotter burns caused a serious loss in cane quality. These results should be considered in the harvesting program, especially under conditions of very dry foliage late in the season or following freezes which result in dry foliage. Further study is needed in the area of varietal response and in situations where paraquat is used as a dessicant prior to burning.

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We wish to thank the other Departments of U. S. Sugar Corporation for their cooperation in this study.

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VARIATIONS OF NON-SUCROSE SOLIDS IN SUGARCANE, I. POTASSIUM[1]

J. E. Irvine
U. S. Sugarcane Field Laboratory
Agricultural Research Service, USDA
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

ABSTRACT

Potassium is the most abundant mineral element in sugarcane juice; processing concentrates the potassium in the final molasses, where high levels inhibit the crystallization of sucrose. Crusher juice samples of sugarcane from replicated variety tests were assayed for K^+ by an ion-selective electrode. Despite large variations within tests, differences in K^+ content were statistically significant among the seven varieties and nine locations tested. Potassium concentration was lowest in the juice of CP 61-37 and highest in L 61-67. However, the range of differences among locations was six times greater than that among varieties. Differences among locations may be due to fertilizer practices. Juice from cane tops contained nearly twice the amount of K^+ found in the lower stalks, but the concentration decreased in the tops, while it remained unchanged in the stalks as the harvest season progressed.

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[1] Only the Abstract of the paper was available for the Proceedings.

VARIATIONS OF NON-SUCROSE SOLIDS IN SUGARCANE
II. STARCH[1]

J. E. Irvine
U. S. Sugarcane Field Laboratory
Agricultural Research Service, USDA
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

ABSTRACT

Cane carbohydrates include starch, which is the most abundant polysaccharide in the juices of undamaged sugarcane. Although starch content of sugarcane is too low for commercial recovery, it is of economic significance. Starch is extracted in a granular form by milling and it would be removed along with muds, if it were not partially solubilized by heat during clarification. Solubilized starch increases the viscosity and slows the crystallization of sucrose. Crusher juices of seven sugarcane varieties from nine replicated test fields were assayed for starch by a colorimetric technique based on anthrone. Statistically significant differences in starch content among varieties were observed; NCo 310 had the lowest starch content and L 61-67 the highest. Highly significant differences were also observed among locations, and the range of differences was greater among locations than it was between varieties. Locational differences may be caused by lodging, poor growth or the inclusion of portions of tops in machine-harvested cane. Sugarcane tops in one test were much higher in starch than the stalks, but variety differences in the starch content of tops were not distinct.

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[1] Only the Abstract of the paper was available for the Proceedings.

SUGARCANE SMUT - AN EMINENT THREAT TO THE U. S. MAINLAND

Norman I. James
Staff Scientist
National Program Staff, ARS-USDA
Beltsville, MD 20705

Culmicolous sugarcane smut incited by Ustilago scitaminea H. & P. was one of the first diseases of sugarcane to be recognized because of its conspicuous symptoms. The usual pattern has been characterized by substantial losses in an industry following establishment of the disease in a new production area. As resistant varieties replace susceptible varieties, losses decline, the disease ceases to be economically important, and then outbreaks occur only if susceptible varieties are again placed in commercial production.

DISTRIBUTION

Sugarcane smut was first discovered in Natal around 1877 (1). The first official report of smut in Mauritius was made in 1915, but the disease had been known to be present before 1882. The disease was considered the chief disease problem in Southern Rhodesia in 1947. Smut was discovered in Kenya in 1958 (7) and also occurs in Pakistan, the Philippines, India, China, Taiwan, and Java.

The disease was confined to the Eastern Hemisphere until it appeared in Argentina in 1940. There were apparently erroneous reports of the disease in Trinidad and British Guiana (presently Guyana) in the early part of the 20th Century. By 1943, many thousands of acres of cane were abandoned in Tucuman Province, Argentina, and the industry was near collapse. By 1946, however, resistant varieties had overcome the crisis. Smut was present in Paraguay in 1944 and in Brazil in 1948. Sugarcane smut was the only important disease in Bolivia in 1957.

The disease was discovered in Hawaii in 1971, in Guyana in 1974, in Trinidad in April 1976, and in Jamaica in November 1976. Sugarcane smut is now located in the tropical storm track about 600 miles from the Florida cane-growing area. Spores could possibly be blown into Florida, Louisiana, or Texas by a tropical storm that approaches the mainland from the Caribbean area. It is also possible that the disease could be introduced by man. James (4) has suggested that it is more likely that smut came to Guyana and Martinique on trade winds from West Africa than from Argentina or Brazil because of ill-defined wind currents over the South American continent.

SYMPTOMS

The characteristic symptom of smut is a long whip-like structure that develops from the apex of the affected stalk. The structure is pencil-like in diameter and varies in length from a few inches to a few feet (Fig. 1). Short whips are straight or slightly curved, and long ones are usually doubled back to give the whip-like appearance. On emergence, the whip is covered with a silver-white membrane that soon ruptures to release a black or brownish mass of spores. Additional symptoms include reduction of stalk size and modification of cross sectional shape, sunken nodes and deepening of the bud-groove, alteration in size and shape of leaves and leaf sheaths, "grassy shoot" appearance caused by production of unusually large numbers of thin, spindly stalks, side shoots or "lalas" that terminate in a whip, leaf galls, and stem cankers (2).

TRANSMISSION

Clamydospores from smutted whips are disseminated by wind and come in contact with standing cane or the soil surface. Infection usually occurs by spores gaining entry behind bud scales in standing cane or in the soil at or after planting. When an infected bud begins to develop, the fungus also starts to grow and keeps pace with the growing tip (1). Eventually, a whip-like structure is produced from the apex of the stalk. In standing cane, infected buds may give rise to smutted whips during the same season, or the mycelium may remain dormant within the buds until cuttings are planted. Spores remain viable in the soil for a few months, depending on moisture and temperature conditions.

ECONOMIC IMPORTANCE

Economic losses have ranged from negligible proportions to levels serious enough to threaten the existence of the industry. Losses ranging from 10% to 50% are common (1). Planting heavily infected seed cane of a susceptible variety often results in total loss. Losses in ratoon or stubble crops are usually higher than those occurring in plant crops.

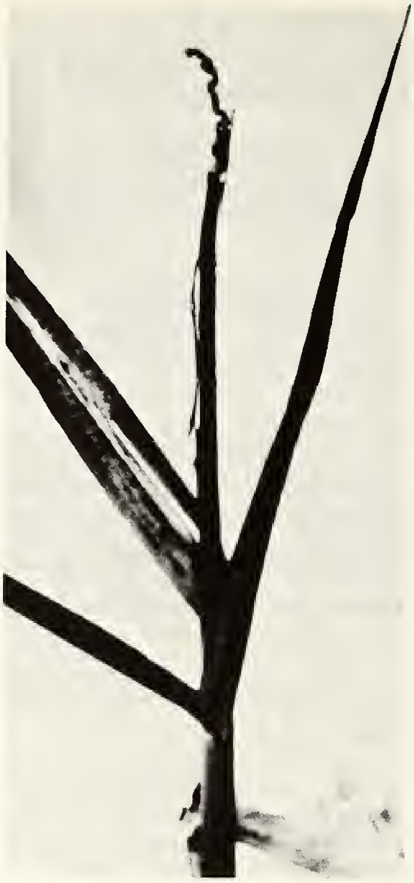

Fig. 1. Sugarcane stalk showing smut whip which developed from the apex of stalk.

CONTROL

The use of resistant varieties offers the only satisfactory means of control. Depending on the level of resistance, other control measures may be required along with resistant varieties. Roguing diseased shoots or stools, as soon as symptoms appear, was reportedly as effective in some countries. In Rhodesia, smut whip removal was determined to be a better control measure than removal of infected stools (3).

Selecting healthy planting material is important. Cuttings from diseased stools are likely to contain mycelia and give rise to smutted plants. Cuttings from smutted fields may be surface contaminated with spores and produce smutted plants.

The long hot-water treatment that is recommended for controlling Ratoon Stunting Disease will also control smut. This procedure is expensive and is only partially effective where large amounts of inoculum are present to reinfect treated cane.

Avoiding the ratooning or stubbling of infected fields has been suggested as a means of controlling smut. This control measure is not likely to be economically feasible unless the susceptible variety that is infected is replaced with a resistant variety.

Starving smut spores in the soil through crop rotation with a nonsusceptible crop could be a useful control method in some sugarcane producing areas. This practice would not be acceptable where monoculture with sugarcane is the standard practice because of lack of suitable alternate crops.

RESISTANCE OF U. S. MAINLAND VARIETIES

During the 1960's, several mainland clones were tested for reaction to smut in India under a PL 480 Project. Most of the clones that were tested in India are no longer of commercial importance, but breeding lines established by crossing to Saccharum spontaneum clones (IA series) were smut resistant when tested in Hawaii in 1972-76 (6).

After smut was discovered in Hawaii in 1971, numerous mainland clones were tested there for reaction to the disease. Some mainland clones were also tested in Rhodesia and more recently in Brazil. Informal arrangements were made to test mainland clones in Pakistan and Sri Lanka, but reaction of varieties in those countries is not yet available.

Available data on reaction of current commercial varieties is presented in Table 1, along with the rating scale that is used in Hawaii. Races of the organism exist and may account for the variation in reaction of particular clones in different countries. Several methods of testing are employed, and this may also contribute to variation in reaction of clones in different countries.

Table 1. Reaction of commercial mainland sugarcane varieties to smut.

	Location			
Variety	Hawaii	Rhodesia	Brazil	India
CL41-223	--	--	--	VS[3]
CL54-378	7[1]	--	--	--
CP52-68	--	4.2(6)[2]	S	S
CP48-103	3	5.0(6)	--	MR
CP56-59	--	2.2(5)	--	--
CP57-603	9	7.7(9)	8	--
CP57-614	4	--	--	--
CP61-37	1	1.5(4)	--	--
CP62-374	7	2.7(6)	--	--
CP63-588	1	0.8(5)	--	--
CP65-357	7	--	--	--
L60-25	6	3.0	--	R
L62-96	--	5.7	7	MR
L65-69	7	--	4	--
NCo310	9	9.0(9)		

[1] Rating scheme in Hawaii:

Stools infected (%)			
Plant	Ratoon	Grade	Reaction
0 - 3	0 - 6	1	
4 - 6	7 - 12	2	Resistant or tolerant
7 - 9	13 - 16	3	
10 - 12	17 - 20	4	
13 - 25	21 - 30	5	Intermediate
26 - 35	31 - 40	6	
36 - 50	41 - 60	7	Susceptible
51 - 75	61 - 80	8	
76 -100	81 -100	9	

[2] Maximum rating in tests

[3] R = resistant, MR = moderately resistant, S = susceptible, VS = very susceptible.

In Hawaii, more than 60% of all clones were susceptible to smut (5). Mainland clones can be expected to exhibit a similar amount of susceptibility. A second race of smut was identified in Hawaii in May 1976, and it appears that about 30% of the clones that were resistant to the first race will be susceptible to the second race.

PLANS FOR TESTING MAINLAND CLONES IN JAMAICA

A Cooperative Agreement was established between the Agricultural Research Service and the Sugar Industry Research Institute, Mandeville, Jamaica, to test about 600 clones during the 4-year period 1977 to 1981 (Table 2). The mainland sugarcane industry has provided a quarantine greenhouse in Jamaica for post-entry quarantine. Approximately 300 clones were sent to the Beltsville quarantine facility in January 1977 and then to Jamaica in December 1977. An additional quarantine of 8 to 10 months is required in Jamaica before the clones are released for field testing for reaction to smut. If the testing program is carried out on schedule, the first data on reaction in the plant crop of 300 clones will be collected in the spring of 1979. Data in the first ratoon crop will be collected in the fall of 1979. Reaction on the second series of 300 clones will be completed in the fall of 1980.

It is important to determine reaction of commercial clones, promising clones in advanced stages of testing, and parental clones to the race of smut in Jamaica. This will permit industry to adjust acreage of clones in preparation for entry of smut, influence release and expansion of promising clones, and allow breeders to begin incorporation of smut resistance in variety development programs.

Table 2. Proposed program for testing U. S. sugarcane clones in Jamaica for reaction to smut.

Time Period	Activity
January 1977	Send 300 clones to Beltsville quarantine from Canal Point, Houma, Baton Rouge, and Clewiston.
December 1977	Send 300 clones to Jamaica from Beltsville quarantine. Send additional 300 clones to Beltsville quarantine from Canal Point, Houma, etc.
June-September 1978	Release 300 clones from Jamaica quarantine for field testing. Send 300 clones to Jamaica from Beltsville quarantine. Send 300 clones to Beltsville quarantine from Canal Point, etc.
March 1979	Collect smut reaction data on plant crop of Field Test 1 and harvest crop.
September 1979	Collect data on smut reaction in first ratoon of Field Test 1, harvest, and plow out. Release 300 clones from Jamaica quarantine and establish Field Test 2 (include apparently resistant clones from Field Test 1). Assess smut situation and make decision about sending additional clones to Beltsville and Jamaica.
March 1980	Collect data on plant crop of Field Test 2 and harvest crop.
September 1980	Collect data on first ratoon crop of Field Test 2. Other activities would depend on decision made in September 1979. If it were decided to continue the project, Field Test 3 would be initiated and additional clones sent to Jamaica and Beltsville quarantine. The September 1977-September 1980 cycle would continue as long as desired.

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PRODUCTION DIFFERENCES BETWEEN PLANT AND RATOON CROPS OF FLORIDA SUGARCANE

G. Kidder
Agricultural Research and Education Center
Belle Glade, Florida

ABSTRACT

Average differences in production of sugarcane and 96° sugar between plant and ratoon crops were calculated from published research data. First ratoon sugar per acre was 86.0% of plant crop sugar per acre; second ratoon was 78.2% of plant. First ratoon cane per acre was 80.6% of plant cane per acre; second ratoon was 73.2% of plant. When compared with commercial production records, the differences between crop years calculated from experimental data were smaller than the differences calculated from commercial data. Estimates were made of the influence of plant, first, second, and all subsequent ratoons on the overall production of the Florida sugar industry for the crop years 1968 through 1975.

INTRODUCTION

The decrease in production of sugarcane and other perennial crops during the years following planting has been the subject of considerable study. This subject was reviewed by Plucknett, et al. (4). In Florida, the number of sugarcane ratoon crops harvested ranges from 0 to 10 but presently averages between 2 and 3. The decision to plow out a planting of cane is generally made when the tonnage of cane harvested per acre drops below a level considered acceptable by the producer. Guidelines for stubble replacement provided by Halsey (2) placed emphasis on returns from sugar, the time costs of fallowing, and the production potential of each field.

In Florida, plant cane generally grows for several months longer than ratoon cane and thus usually yields higher tonnages of cane and sugar at harvest. Producers often make note of the proportion of their total acreage in plant cane when referring to their expected production. Recent work (1) has shown that solar radiation and degree days are much more important than percent acreage in plant cane in influencing average annual yields of the Florida sugarcane industry. Definition of the rate of production decrease would help avoid problems caused by exaggeration of the importance of plant cane.

Objectives of this study were to estimate the rate of decrease in production of cane and sugar in Florida as a function of crop age (plant, first, and second ratoon crops) and to test the estimates against commercial production records.

MATERIALS AND METHODS

In this study the influences of variety, soil, geographical location, and basic management practices were minimized by using data from the final phase (Stage IV) of the Florida variety development program. Stage IV consists of large replicated plots of promising varieties planted in eight representative locations of the sugarcane growing region. Variety CP 63-588, presently the most widely grown variety in Florida (3), has been included as a test cane or as the check variety in these trials since 1966 (5 to 12). Thus, it was possible to obtain data for the same variety planted under similar conditions in the same locations for several consecutive years. Using all available data, the tons of cane and indicated 96° raw sugar per acre were compiled for the eight years 1968 through 1975 (Table 1). Production performance of the different crop ages (plant, first, or second ratoon) within a crop year were compared rather than comparing the production performance of the successive crops of the same planting of cane over three years.

Commercial production data, representing 10 to 20% of the Florida sugarcane acreage, were compiled for the same eight years. Sugar and cane produced by the first and second ratoon crops were calculated as percentage of the plant cane crop in each year. The averages of the eight years were compared with the rates calculated by simple linear regression of production data and successive crop years.

To estimate the influence of crop age on the overall sugar production of the industry, two assumptions were made. First, the average production of all ratoons subsequent to the second was assumed to have the same percentage decrease as found between the first and second ratoons. Second, all acreage in plant cane one year was assumed to be in first ratoon cane the following year and in second ratoon in the third year. The acreage of cane harvested for sugar as plant, first, second, and "all other" ratoons was calculated using reported total acreages (13) and percent plant cane.[1/] The contribution of each age category of cane to the total production for each year was then calculated using the acreages noted above and the age-production values found in the variety trials for those years.

[1/] From annual Florida sugarcane variety census reports, e.g. (3).

Table 1. Average sugar and cane per acre produced by CP 63-588 in variety trials for all locations harvested.[1]

Harvest year	Sugar per acre			Cane per acre		
	Plant cane	First ratoon	Second ratoon	Plant cane	First ratoon	Second ratoon
	tons					
1968	5.41	5.02	4.56	56.68	46.60	41.22
1969	5.89	6.07	5.49	58.33	53.09	47.60
1970	5.59	4.76	5.22	49.48	39.96	42.86
1971	6.34	4.70	3.96	57.19	39.94	34.05
1972	6.80	6.37	5.30	60.15	55.94	48.04
1973	7.46	5.25	4.96	62.24	44.21	40.14
1974	6.95	5.86	4.75	59.75	47.35	39.38
1975	6.92	5.82	5.47	61.57	48.11	45.81

[1] Years 1968, 1969, and 1970 as reported (9, 10, 11). Weighted averages calculated from reported data for years 1971 through 1975 (5, 6, 7, 8, 12).

RESULTS AND DISCUSSION

Sugar per acre

The results of the calculations are shown in Table 2. In the variety trials first and second ratoon cane averaged 86.0% and 78.2% as much sugar per unit area as plant cane, respectively. This was somewhat higher than the 78.4% and 72.4% found for commercial cane and may reflect fewer production limiting factors in the experimental cane than the average commercial field. Both commercial and variety trial data contained instances where the first ratoon produced more sugar per acre than the plant crop.

Table 2. Sugar per acre and cane per acre of ratoon crops as a percent of plant cane. Comparison of variety trial and commercial results.

Harvest year	Sugar per acre		Cane per acre	
	First ratoon	Second ratoon	First ratoon	Second ratoon
	percent			
Variety trials[1]				
1968	92.7	84.3	82.2	72.7
1969	101.2	91.6	91.0	81.6
1970	85.2	93.5	80.8	86.6
1971	74.2	62.5	69.8	59.5
1972	93.7	77.9	93.0	80.0
1973	72.3	68.3	71.0	64.5
1974	84.3	68.4	79.2	65.9
1975	84.1	79.1	78.1	74.4
8 year average	86.0	78.2	80.6	73.2
Commercial producers[2]				
A	79.1	74.2	79.3	74.5
B	71.2	53.9	77.9	58.9
C			78.8	67.4
Weighted averages	78.4	72.4	79.1	70.3
Differences between variety trial and commercial	7.6	5.8	1.5	2.9

[1] Data for CP 63-588 in variety trials.
[2] Averages of 1968-75.

The linear regression equation derived from the variety trial data predicted average sugar production of 6.34 tons in the plant crop and a decrease of 0.72 tons of 96° sugar per acre per year in the ratoons. By this method of calculating, first and second ratoon sugar production would be 88.6% and 77.2% of plant cane production, respectively. Good linear correlation was found (r = 0.71**) and no improvement was obtained when log of sugar per acre was correlated with crop age.

Cane per acre

Cane tonnage for first ratoon sugarcane in the variety trials was found to be 80.6% of the plant crop. This compared very favorably with the 79.1% value found for the commercial data (Table 2). Second ratoon tonnage was 73.2% and 70.3% of plant cane tonnage for the variety trials and commercial cane, respectively. There is closer agreement between the values found for experimental and commercial cane per acre than there was for sugar per acre.

Good linear correlation (r = 0.80*) was found in the variety data and the equation predicted 57.0 tons of cane per acre (TCA) for plant cane with a decrease of 7.89 tons each successive year. Examination of the average percentage decreases (Table 2) however, shows that the greatest loss in tonnage is between the plant and first ratoon year and that subsequent decreases are less, a generally observed characteristic of sugarcane production. When the linear model was tried on commercial data which covered additional ratoons it was found that the linear model did not fit as well. As may be noted, the differences between crops vary considerably from year to year depending on the many factors which influence production.

From the discussion above, it may be noted that the proportion of plant cane on a farm in a given year has a greater influence on the total cane tonnage than it does on the total sugar produced by that farm. For those concerned with the growing of sugarcane it is easier to appreciate sugarcane tonnage per acre than it is sugar per acre. Thus it is understandable why sugarcane tonnage is the measure of productivity more often used even though revenue is from sugar and not cane *per se*.

The estimated amounts of sugar produced by the various crops of sugarcane for the years 1968 through 1975 are presented in Table 3. By the method used for calculating the values, the differences primarily reflect the different acreages in the four age categories during the period studied. Note may be made that more sugar was produced from first ratoon cane than from plant cane in 1969 and 1973, years in which there was a relatively large percentage of first ratoon cane and a relatively small percentage of plant cane.

Table 3. Estimated sugar produced from the various crops of sugarcane for the harvest years 1968 through 1975.

	Plant		First ratoon		Second ratoon		All other ratoons		Total
Harvest year[1/]	1,000 tons	% of total	1,000 tons	% of total	1,000 tons	% of total	1,000 tons	% of total	1,000 tons
1968	176	32.4	138	25.4	116	21.4	113	20.8	543
1969	159	29.9	174	32.7	144	27.1	55	10.3	532
1970	238	36.7	150	23.1	173	26.6	88	13.6	649
1971	235	37.1	179	28.2	119	18.8	101	15.9	634
1972	361	37.7	238	24.8	192	20.0	167	17.5	958
1973	206	25.2	258	31.5	180	22.0	174	21.3	818
1974	194	24.5	174	21.9	230	29.0	195	24.6	793
1975	403	38.0	196	18.5	186	17.5	276	26.0	1061

[1/] Percent plant cane acreage was 28.8, 28.5, 34.2, 34.6, 33.7, 23.1, 23.7, and 34.0 percent for the eight years, respectively.

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PATHOGENICITY OF FUSARIUM TRICINCTUM AND F. MONILIFORME TO SUGARCANE[1]

H. Koike
USDA, ARS
Houma, Louisiana

ABSTRACT

Fusarium moniliforme and *F. tricinctum* were isolated from freeze-damaged stalks of sugarcane cv L 65-69. Pathogenicity studies with these fungi indicated that they are both mildly pathogenic to sugarcane, and that *F. tricinctum* is less pathogenic than *F. moniliforme*. *F. moniliforme* caused more reddish-purple discoloration in cut whole stalks or pieces of stalks than in stalks of growing cane, and stalks exposed to freezing temperatures appeared more susceptible to discoloration by both fusariums than stalks not exposed to these temperatures. This is the first report of the isolation of *F. tricinctum* from sugarcane and of its pathogenicity to this host.

On November 25, 1970, a light freeze (-3.3 C) occurred at the U. S. Sugarcane Field Laboratory, Houma, Louisiana. There was extensive browning of the leaves but little stalk damage (3). On February 10, 1971, temperatures dropped to -4.4 C and remained at that temperature for 2 hr; there was an 8-hr period of 0 C or lower temperatures.

Although fields of commercial sugarcane are usually harvested by the end of December, a plot of mature cane in a cold tolerance test of the 1970 crop was still standing at the Field Laboratory at the time of the above-mentioned freezes. After the second freeze, stalks from several cultivars were split lengthwise and examined. Internal tissue damage was variable, and in cv CP 65-350 and L 65-69 there was no unfrozen tissue above ground (3). There was extensive reddening of the internal stalk tissue. *Fusarium moniliforme* Sheld. and *F. tricinctum* Cda. Sacc. (= *F. poae* [Pk] Wr.) were isolated from the discolored tissues of cv L 65-69.

This paper describes pathogenicity studies with *F. tricinctum*, a pathogen that had not previously been reported to affect sugarcane, and compares this species with the well-known sugarcane pathogen, *F. moniliforme*.

MATERIALS AND METHODS

For fungal isolations, sections of stalk of the freeze-damaged L 65-69 were cut from plants, thoroughly washed, surface-sterilized with 0.5% sodium hypochlorite solution, and split lengthwise. Small pieces of discolored tissue were removed aseptically from the node and internode and plated on potato dextrose agar (PDA) and on oatmeal agar amended with streptomycin sulfate (100 ppm).

Two distinct types of *Fusarium* grew out from the sugarcane tissues, and pure cultures were isolated from the two distinct types. The fungi were grown on PDA plates at 25 C for 12-14 days. Spore suspensions in sterilized distilled water were prepared for each fungus by scraping the agar-surface growth that had been covered by a shallow layer of water. The suspension was filtered through cheesecloth, and sufficient sterilized water was added so that a microscopic field at 100x (10 x 10) magnification contained ca 20 conidia.

Before inoculation of whole stalks or cuttings of cane from the 1971 crop, the surface of the stalks was washed thoroughly and surface-sterilized as described earlier. A 4-mm diameter hole was bored into the middle of the internode extending to the central pith area. The spore suspension (0.1 ml) was placed in the hole, and the inoculated internode was covered with a piece of aluminum foil. The controls were treated similarly except that sterilized distilled water was placed in the hole.

Some stalks from the 1971 crop were inoculated and left growing in the field. All other inoculated stalks and cuttings were wrapped in plastic bags and incubated at 10 C for 6 weeks. The stalks and cuttings were then split lengthwise to determine the extent of discoloration.

The discolorations were classified according to the scale developed for red rot disease (*Glomerella tucumanensis* (Speg.) von Arx & Mueller) of sugarcane stalks (1). The classes of resistance, description, and adjective ratings are as follows (1):

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[1] A contribution from ARS, USDA in cooperation with the Louisiana Agricultural Experiment Station.

Class	Description	Adjective
1	Slight lateral and longitudinal spread	Resistant
1+	Nearly reaching nodes longitudinally, but slight lateral spread.	
2	Longitudinal spread extending nearly to nodes and lateral spread occupying half or more of inoculated internode.	Moderately resistant
2+	Longitudinal spread entering nodes; lateral spread as in 2.	
3	Longitudinal spread beyond inoculated internode into adjoining ones, with lateral spread filling or nearly filling inoculated internode.	Susceptible
3+	Longitudinal spread nearly to second node from point of inoculation.	
4	Longitudinal spread through two or more nodes on either side, extensive lateral spread.	Very susceptible
4+	Longitudinal spread through entire stalk; extensive lateral spread, but nodes not showing natural infection.	

Re-isolations of the fungi were made from tissue pieces taken from discolored areas of the nodes and internodes.

Two types of experiments were conducted to determine pathogenicity of the Fusarium isolates to different sugarcane cultivars.

Experiment 1. Twenty three-node cuttings and eight mature stalks growing in the field of L 60-25, L 62-96, L 65-69, CP 52-68 and CP 61-37 were each inoculated separately with F. moniliforme and F. tricinctum on September 29, 1971. Cuttings were inoculated in an internode between two nodes, and stalks were inoculated in the internode below the node to which the seventh youngest leaf was attached.

At the end of the incubation period, five to nine cuttings of L 62-96, L 65-69, and CP 52-68 from the different treatments were planted in flats of steam-sterilized vermiculite. The flats were placed on a greenhouse bench, and germination counts were made 4 weeks later.

Experiment 2. Ninety stalks of field-grown L 65-69 from the 1971 crop were harvested on December 22, 1971. These stalks had not been exposed to freezing temperatures in the field. These were assigned at random to nine 10-stalk bundles, and these bundles were divided into three groups of three bundles each. One group was frozen at -5.6 C for 2 hours in a temperature-controlled chamber; the second group was frozen at -5.6 C for 4 hours, and the third group was not frozen. One bundle from each group was then inoculated with F. moniliforme, one with F. tricinctum, and one was inoculated with water only. Inoculation of each stalk was in the fourth and eighth internodes from the base of the stalk. All bundles were stored at 10 C for 3 weeks and then were exposed to 18-26 C for 3 days before an additional 3-day incubation at 10 C. Three days later, the stalks were split lengthwise and examined.

RESULTS AND DISCUSSION

The Fusarium isolates were sent to Dr. William C. Snyder, University of California, Berkeley, for species identification. One was identified as Fusarium moniliforme, which causes Fusarium sett or stem rot in sugarcane (2). The other was identified as F. tricinctum, the causal organism of diseases of several members of the Gramineae, but not of Saccharum (4).

Results of experiment 1 (Table 1) indicate that when cuttings were inoculated, F. moniliforme caused more extensive reddish-purple discoloration than F. tricinctum (Fig. 1) in all of the sugarcane cultivars, with the exception of L 60-25. In the case of L 60-25, discoloration by both fungi was similarly mild. In the other cultivars, discoloration by F. moniliforme extended beyond the nodes of the inoculated internode. When growing stalks were inoculated, both fungi produced mild discoloration in all cultivars, and the discoloration was confined to the inoculated internode.

There was no adverse affect on germination of L 65-69 and CP 52-68 by either fungus, but F. moniliforme reduced germination of L 62-96 by 36% of that of the control; F. tricinctum reduced germination of L 62-96 by 14%.

Results of the experiment with artificial freezes indicated that stalks inoculated with both fusariums after a 4-hour, -5.6 C treatment were discolored slightly more than those inoculated after a 2-hour, -5.6 C treatment, or those which were unfrozen but inoculated (Table 2).

Table 1. Summary of symptom ratings in cuttings and stalks of sugarcane cultivars inoculated with *Fusarium moniliforme* and *F. tricinctum*.

Cultivar	Average symptom rating[a/]			
	Cuttings at 10C		Stalks in field	
	F. moniliforme	*F. tricinctum*	*F. moniliforme*	*F. tricinctum*
L 60-25	2+[b/]	2+	2+	2+
L 62-96	3	2	2	2
L 65-69	3	2	2+	2+
CP 52-68	3	2	2+	2+
CP 61-37	3	2+	2+	2+

[a/] Controls had 1, 1+ = resistant rating.

[b/] 1, 1+ = resistant; 2, 2+ = moderately resistant; 3, 3+ = susceptible; 4, 4+ = very susceptible.

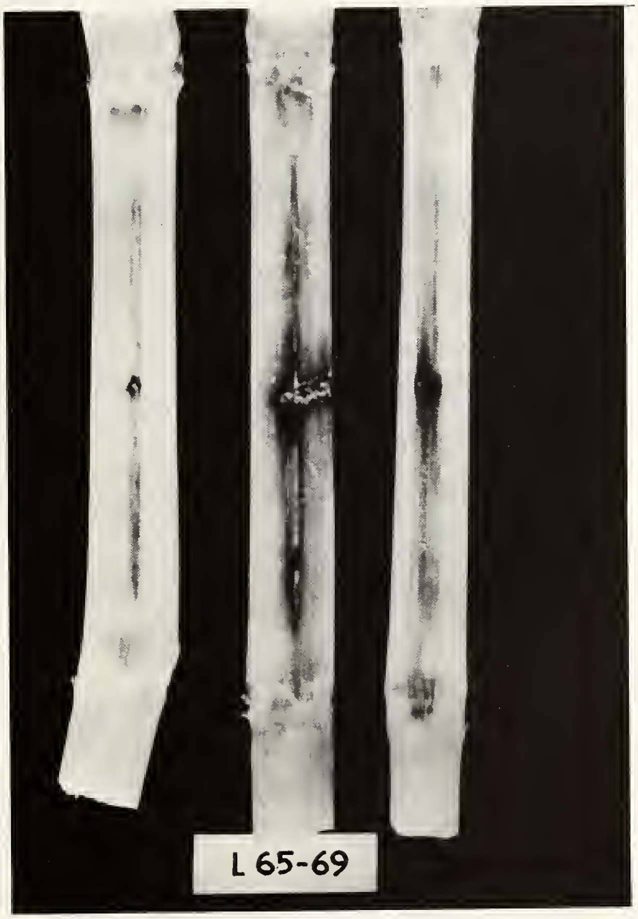

Fig. 1. Stalk symptoms produced on sugarcane cv L 65-69 by inoculation with *Fusarium moniliforme* (center) and *F. tricinctum* (right). Control on left was inoculated with sterilized water only.

In the unfrozen stalks, inoculation with the fusarium resulted in only slightly more discoloration than in the uninoculated controls.

In both experiments, the respective *Fusarium* was reisolated from the discolored nodal or internodal tissues of the inoculated stalks or seedpieces. *F. moniliforme* and *F. tricinctum* were not isolated from tissues of the controls.

Table 2. Summary of symptom ratings of sugarcane cv L 65-69 stalks exposed to artificial freeze treatment and inoculated with Fusarium moniliforme and F. tricinctum.

	Average symptom rating in stalks		
		Frozen (-5.6C)	
Inoculated	Not frozen	2 hr	4 hr
Water control	1[a/]	1	1+
F. moniliforme	1+	2	2+
F. tricinctum	1+	1+	2

[a/] 1, 1+ = resistant; 2, 2+ = moderately resistant; 3,3+ = susceptible; 4, 4+ = very susceptible.

Results indicate that both Fusarium moniliforme and F. tricinctum isolates used in these experiments are mildly pathogenic to sugarcane; F. tricinctum was less pathogenic than F. moniliforme. F. moniliforme has been reported to cause severe rotting of sugarcane stalks and seedpieces, and marked reduction in germination of shoots from planted seedpieces (2). It is possible that the isolates of F. moniliforme used in the experiments reported here are those of a mild strain. It is also possible that the sugarcane cultivars used have relatively high resistance to Fusarium stalk and sett rot.

This is the first report of the isolation of F. tricinctum from sugarcane and of its pathogenicity to this host.

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ASSESSMENT OF RAT DAMAGE TO FLORIDA SUGARCANE IN 1975

Lynn W. Lefebvre, Charles R. Ingram,[1] and Mark C. Yang
U. S. Fish and Wildlife Service
Denver Wildlife Research Center
Gainesville, Florida
and
U. S. Fish and Wildlife Service
Denver Wildlife Research Center
Sandusky, Ohio
and
Department of Statistics
University of Florida
Gainesville, Florida

ABSTRACT

Depredations by rats (Sigmodon hispidus, Rattus rattus, and Neofiber alleni) on Florida sugarcane were assessed during the 1974-75 harvest season. Stalks totalling 68,925 from 41 fields were examined for rat damage. Incidence of damaged stalks ranged from 4.5 to 38.6% per field, with a mean of 14.0%. Mean damage in field centers was greater than that in field edges and middle ditch borders. Sample size for future field testing of candidate rodenticides in Florida sugarcane was determined: in order to detect a treatment effect of 50% damage reduction, a test at the 95% confidence level with 31 treatment and 31 control plots (half fields) should have a 95% probability of detecting this difference; at the 90% confidence level, 10 treatment plots and 10 control plots should detect this difference with a 70% probability. Damage was not significantly correlated with field age (ratoon), percentage sugar yield, brix, pol, or harvest date, but was negatively correlated with tons of cane harvested per acre for 28 of the 41 fields from three adjacent plantations. Economic loss caused by rat damage was estimated at approximately $95.00/acre in one grower/processor's crop (based on the 1970-75 mean price for raw sugar: $0.146/lb).

INTRODUCTION

In 1974, the U. S. Fish and Wildlife Service began several studies on rats and their damage to sugarcane in Florida. The purpose of these studies is to obtain data for designing future field tests to evaluate rodent control methods. The study reported here was an assessment of rat damage during the 1974-75 harvest. This study was supported in part by the Florida Sugar Cane League.

The major objectives of the harvest damage assessment were to estimate rat damage distribution within fields, variances between whole field units and half field units within whole fields, and sample size requirements for testing efficacy of candidate rodenticides in Florida sugarcane. Although the study was not designed to obtain an accurate estimate of rat damage in the area samples, significant correlation between rat damage and tons of cane harvested per acre was found for sample fields in several adjacent plantations. Therefore, a crude estimate of economic loss was made, based on a linear regression of tonnage on percentage stalks damaged.

METHODS

Damage was assessed in 40 hand-harvested fields owned by the U. S. Sugar Corporation. The distribution of sample fields (Fig. 1) was determined primarily by the harvesting schedule during the study period (January-March 1975). The highest concentration of sample fields was in three plantations: Wetherald, Miami Locks, and South Shore. An additional hand-harvested field, owned by Okeelanta Division of Gulf and Western Foods, was also assessed. This field was located approximately four miles south of the southeastern corner of South Shore plantation.

Fields were stratified to proportionally sample three areas of each half field (the edge, middle, and middle ditch; Fig. 2) to determine if damage is equally distributed throughout fields, or if it tends to be heavier in particular areas. One sample was randomly selected per pile row in Strata II, III, and the long portion of I. Three additional samples were selected from the short portions of Stratum I on each half field. Sampled fields averaged about 36 acres. The number of pile rows per whole field varied from 52 to 64, with a mean of 60. The number of samples assigned to Strata I and III per field (20 and 14 respectively) was fixed, so that variation in number of pile rows was absorbed by Stratum II. Mean damage determinations for strata were weighted to calculate field means. Weighting factors were calculated for each half field from the products of strata lengths and pile rows per stratum. For example, if a half field contained 17 pile rows in Stratum II, weighting factors would be calculated as follows:

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[1] Present address: Lederle Laboratories, Pearl River, New York.

Stratum		Weighting factor
I	7(1200) + 17(300) = 13,500	.3629
II	17(900) = 15,300	.4113
III	7(1200) = 8,400	.2258

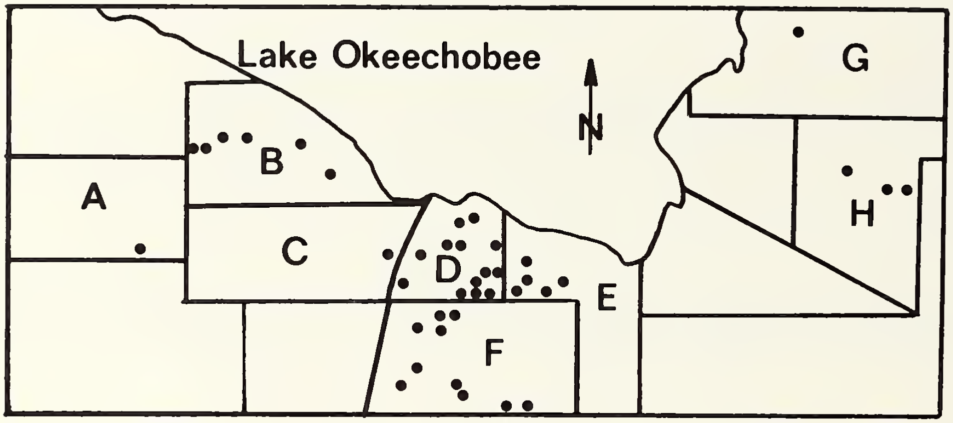

Fig. 1. **Letters represent U.S. Sugar Corporation plantations. Dots represent fields assessed for rat damage.**

A. **Townsite**
B. **Ritta**
C. **Mott**
D. **Miami Locks**
E. **South Shore**
F. **Wetherald**
G. **Runyon**
H. **Prewitt**

Scale: 1/4 inch = 1 mile

Fig. 1.

Twenty-five stalks were selected for each sample and examined for rat damage. Care was taken to avoid looking at the stalks while pulling them from the pile row. The number of internodes damaged, if any, was recorded for each stalk examined.

RESULTS

A total of 68,925 stalks was examined. Rat damage, expressed in mean percentage of examined stalks damaged per field, ranged from 4.5 to 38.6 and averaged 14.0% ± 2.38 (S.E.(1.96)). Internodes damaged per sample ranged between field means of 2.4 and 42.7, with an overall mean of 9.1 ± 2.47.

Percentages of stalks damaged per stratum in the 40 U. S. Sugar Corporation fields are shown in Table 1. A multiple comparison of strata means using Bonferroni's Inequality (Feller 1968) showed all strata means to differ significantly from each other ($P < 0.01$). Thus the greatest percentage of stalk damage was found in Stratum II, the field center, and the lowest was found in Stratum I, the field edge. Although these differences between strata are significant, they are not large. The important finding is that rats are at least as active in the field centers as in the edges.

Samol (1972) reported that greatest rat damage occurred 20-40 feet from field edges. He sampled more fields in his study (94 twenty-acre fields), but had fewer samples per field (10). Stalks per sample were the same as in the present study (25). Samol used the same pattern of sampling in each field, whereas in the present study, half field units were stratified and one or two random samples were selected per pile row.

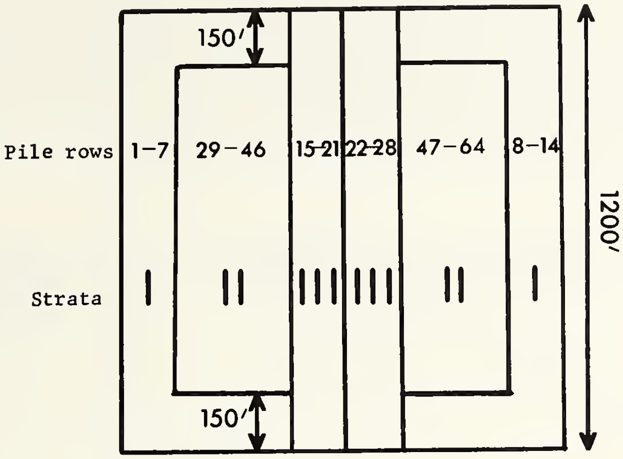

Fig. 2. Field layout for harvest damage assessment.

Table 1. Damage in strata of 40 fields, 2 halves per field.

Stratum	Mean % stalks damaged	Mean No. internodes damaged per sample point
I	13.3	8.6
II	14.7	9.8
III	13.8	9.1

Mean number of internodes damaged per sample point did not differ significantly between field strata. Variation in numbers of internodes damaged between samples was greater than variation in percent stalks damaged.

Variation components were estimated according to a nested design model,

$$Y_{ij} = \mu + \alpha_i + \beta_{ij}$$

where:

Y_{ij} = total damage at jth half of the ith field
μ = mean damage
α_i = random effect due to field i which is normally distributed about a zero mean with variance σ_α^2
β_{ij} = random effect due to half field j within field i which is normally distributed about a zero mean with variance σ_β^2

Estimates of these parameters, based on the fractions of stalks damaged in 40 fields are:

$\mu = 0.140$

$\hat{\sigma}_\alpha^2 = 0.00539$

$\hat{\sigma}_\beta^2 = 0.00162$

If half fields are randomly picked to estimate u, tjem tje variation among half fields is estimated as

$$\widehat{\mathrm{Var}\ (Y_{ij})} = \hat{\sigma}_\alpha^2 + \hat{\sigma}_\beta^2 = 0.00539 + 0.00162 = 0.00701$$

If fields are chosen to estimate μ in half fields, then the estimate is $Y_i = \frac{1}{2}(Y_{i1} + Y_{i2})$, and the variance among fields is estimated as

$$\widehat{\mathrm{Var}\ (Y_i)} = \hat{\sigma}_a^2 + \frac{1}{2}\hat{\sigma}_{\beta}2 = .00539 + \frac{1}{2}(0.00162) = 0.00620$$

The variability of damage between halves of the same field is relatively small, therefore it appears reasonable to utilize half fields instead of whole fields in rodenticide field tests.

Sample sizes (i.e., number of treatment and control fields) for a field test were calculated by the method of Sokal and Rohlf (1969); results appear in Table 2. For a specified significance level, if sample size is reduced, the probability of detecting damage reduction is reduced. A 50% damage reduction was selected as efficacious; a greater reduction could be detected with fewer sample fields at a given significance level. Utilization of sample size data (e.g. Table 2) enables those conducting a field test to predict the reliability of results in accordance with field test magnitude, which is frequently limited by economic constraints.

Table 2. Approximate numbers of treatment half fields required to detect a 50% damage reduction in a rodenticide field test. Equal number of control half fields must be utilized.

Significance level	Number of half fields				
.01	46	38	29	24	16
.05	31	25	18	14	10
.10	25	19	13	10	6
Power*	.95	.90	.80	.70	.50

*Probability of detecting a 50% damage reduction due to treatment.

For all 41 fields, rat damage was not significantly correlated with any of the production parameters tested: tons of cane per acre, sugar yield, field age, date of harvest, or juice quality (brix or pol) ($P > .10$). However, since the majority of the sample fields (28) came from three adjacent plantations, data from these fields were subjected to a separate correlation analysis. The results of this analysis (Table 3) indicated that only tons of cane per acre was significantly (negatively) correlated with rat damage (fitted equation for this relationship is given in Fig. 3).

Table 3. Correlation of production parameters with percentage stalks damaged for 28 fields assessed in Wetherald, Miami Locks, and South Shore plantations.

Parameter	r*	P
Tons cane harvested per acre	-.581	<.01[a]
Brix	.312	NS[b]
Pol	.269	NS
Percent sugar yield	.264	NS
Field age (ratoon)	.218	NS
Harvest date	.078	NS

*Linear correlation coefficient
[a] t = 3.64
[b] NS = non-significant; P > .10

Tonnage is also expected to decrease with age, primarily from planting through harvest of the first ratoon crop. Samol (1972) found that rat damage to Florida sugarcane increased from plant cane to second ratoon, but not from second to fourth ratoon. No plant cane fields and two first ratoon fields were represented by the 28 fields used in the correlation analysis; mean field age was third ratoon. A significant correlation between field age and tonnage was found in this study ($r = -0.443$, $t = 2.52$; $P < 0.02$). The significant correlation between damage and tonnage, and the lack of correlation between damage and field age indicate that rat damage and ratoon may both influence tonnage, but that damage is not necessarily greater in older fields.

Twenty-three of the 41 fields assessed were variety Cl 41-223. No other variety was represented by more than five sample fields. A comparison of mean fraction of stalk damage of Cl 41-223 versus the mean of all other varieties combined was non-significant ($t = 0.927$). Mean damage and tonnage of the assessed fields is summarized by variety in Table 4.

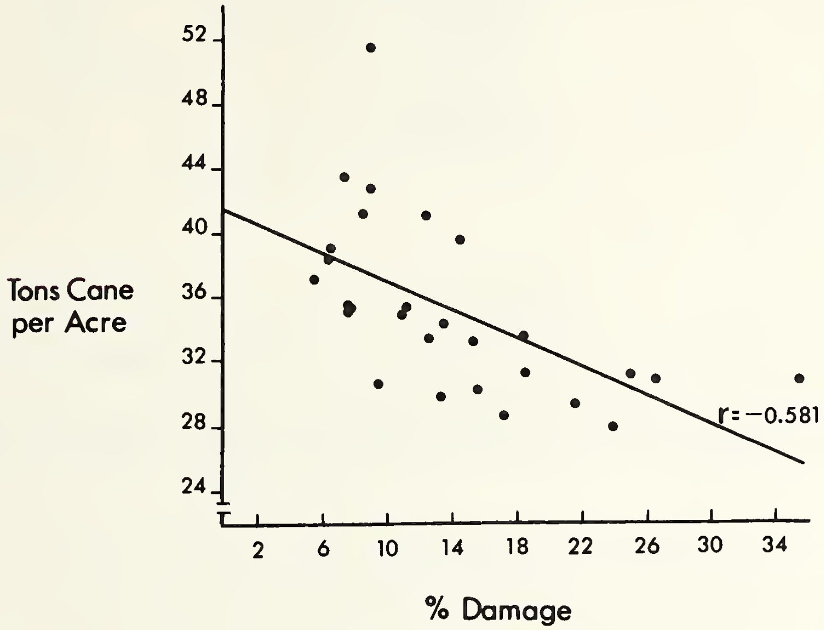

Fig. 3. Tons of cane per acre and percent stalks damaged with equation $\hat{Y} = 41.26 - 43.17 X$ fitted by linear regression.

Table 4. Mean field damage and tons of cane harvested per acre by sugarcane variety.

Variety	n	% stalks damaged $\bar{X}$ (S.D.)	Mean tons/acre $\bar{X}$ (S.D.)
Cl 41-223	23	15.0 (9.31)	32.1 (7.10)
Cl 54-336	5	11.8 (4.93)	28.9 (9.76)
Cl 54-378	5	9.7 (2.22)	41.4 (6.66)
Cl 59-2	2	19.4 (3.26)	29.0 (0.48)
Cl 49-200	2	13.9 (0.49)	39.9 (0.71)
Cl 54-312	2	10.6 (4.16)	28.2 (8.36)
Cl 59-1167	1	24.9	31.4
CP 62-374	1	9.1	42.6

The fitted regression equation given in Fig. 3 predicts a mean tonnage value (Y) of 41.26 if percentage stalks damaged (X) equals 0. This extrapolation suggests that 41.26-35.24 (Y intercept - mean tonnage), or 6.02 tons/acre were lost as a result of rat damage in Wetherald, Miami Locks, and South Shore plantations. However, the relationship of tonnage with damage is confounded with the relationship of tonnage with many other variables, such as field age, cane variety, soil, weather, disease, insect damage, and possibly stalk density. If high tonnage producing fields consistently had more stalks than low tonnage fields, the estimate of tonnage loss due to rat damage could be inflated. However, within a given cultivation area, cane variety is an important determinant of the number of stalks per acre (Le Grand 1972). Of the 28 fields assessed in Wetherald, Miami Locks, and South Shore plantations, 13 were variety Cl 41-223. Within this variety, the tonnage/rat damage relationship was more homogeneous ($r = -0.722$; $t = 3.461$; $P < 0.01$).

Because age and other factors may have influenced tonnage to an unknown extent, the estimated loss caused by rat damage was reduced from 6.02 tons/acre to 3.00 tons/acre in order to make a relatively conservative estimate of economic loss (Table 5). Even within a single grower's acreage. tons per acre and sugar yield can vary considerably, therefore extrapolation of loss estimate data from fields assessed in this study to fields of other growers might not be justified.

Table 5. Estimated economic loss caused by rat damage in a Florida sugar company. Calculations are based on an estimated loss of 3 tons/acre as a result of rat damage.

	Wetherald, Miami Locks, South Shore Plantations		All plantations	
Acres	12,535		65,268	
Loss in tons cane	37,605		195,804	
Loss in pounds raw sugar	8,573,940 @ 11.4% yield		42,293,664 @ 10.8% yield	
Raw sugar price*	1975 .225/1b	1970-75 mean .146/1b	--	
Dollar loss	@ 1975 price $1,929,136.	@ 1970-75 mean $1,251,795.	@1975 price $9,516,074.	@ 1970-75 mean $6,174, 875.

*From Lamborn Sugar Market Reports, January 1975 and 1977.

CONCLUSIONS

These results have several implications for field testing of candidate rodenticides in South Florida cane.

Since field centers, on the average, had the greatest percentage of stalks damaged, assessment samples could be taken in this stratum alone. If samples are taken over whole or half fields, they should be stratified.

If a rodenticide treatment can reduce rat damage by 50%, a test using 10 treatment and 10 control half fields has approximately a 70% probability of demonstrating efficacy at the 90% confidence level. Ideally, all variables but that being tested (treatment effect) should be identical in treatment and control plots. Since even known variables, such as cane variety and ratoon, may be difficult to replicate, a precedence of criteria for sample field selections was established on the basis of results of the present study.

1) geographical proximity;
2) field age -- plant cane and first ratoon fields should be avoided;
3) variety -- if more than one must be used, all selected varieties should have equal opportunity to be represented in treatment and control plots;
4) harvest date proximity

The correlation between rat damage and tonnage in the area most heavily sampled by this study (Wetherald, Miami Locks, and South Shore plantations) indicates that rats can have a significant impact on sugarcane production. Rat damage was estimated to have caused a loss of several million dollars to one sugar growing/processing company.

ACKNOWLEDGMENTS

The Florida Sugar Cane League's partial support of this study is gratefully acknowledged. The cooperation of the U. S. Sugar Corporation and Okeelanta Division of Gulf and Western Foods is greatly appreciated. J. Wayne Beardsley, Jr., U. S. Sugar Corporation, coordinated the selection of sample fields and provided production data on these fields. Steven Williams and Alan Braley, U.S.F.W.S. cooperative education students, conducted the damage assessment. N. R. Holler and D. G. Decker conducted preliminary investigations on sampling procedures.

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ASSESSMENT OF ZINC PHOSPHIDE-TREATED-BAIT ACCEPTANCE BY COTTON, BLACK, AND FLORIDA WATER RATS AND DETERMINATION OF ACUTE ORAL TOXICITY OF ZINC PHOSPHIDE TO THESE SPECIES

Lynn W. Lefebvre, Nicholas R. Holler, David G. Decker
U. S. Fish and Wildlife Service
Denver Wildlife Research Center
Gainesville, Florida

Nancy J. Shafer
Department of Statistics
University of Florida
Gainesville, Florida

ABSTRACT

The median lethal doses (LD_{50}'s) of zinc phosphide for three species of rodents damaging sugarcane in south Florida were determined by oral gavage. LD_{50}'s obtained were: 33, 39, and 42 mg/kg for the cotton, black, and Florida water rat, respectively. In preliminary bait acceptance tests, the bait registered for infield use in Hawaii (1.88% zinc phosphide on oat groats) was tested against a less expensive, more readily available alternative (1.88% zinc phosphide on cracked corn). No major differences in acceptance were observed. Prebaiting with untreated oat groats appeared to enhance consumption by and mortality of black rats, but not cotton and water rats. A larger test of the oat groat bait presented to cotton and black rats demonstrated a differential mortality rate for the two species: 18 of 27 cotton rats (67%) were killed vs 3 of 14 black rats (21%). Because of inherent variability in bait acceptance testing, additional tests are required to properly evaluate this and other formulations of a zinc phosphide/oat groat bait.

INTRODUCTION

A 1.88% zinc phosphide/oat groat rodenticide bait has been registered for use in Hawaiian sugarcane (Pank, 1976). It cannot be assumed that the bait will prove to be efficacious in Florida sugarcane since rodent species differ and cane culture in Florida is quite different than that in Hawaii. Nevertheless, the Hawaiian bait is the best initial candidate for infield use in Florida sugarcane.

The three most important depredators of Florida sugarcane are the cotton rat (*Sigmodon hispidus*), the black rat (*Rattus rattus*), and the Florida water rat (*Neofiber alleni*) (Samol, 1972). Zinc phosphide toxicity to and acceptance of the Hawaiian bait by these target species were tested to determine its potential effectiveness in Florida sugarcane.

Preliminary bait acceptance assays were conducted to determine: 1) if gross differences exist in acceptance of oat groat and cracked corn zinc phosphide baits, 2) if prebaiting results in sizeable increases in consumption of oat groat and cracked corn zinc phosphide baits, and 3) if gross differences exist in bait acceptance by cotton, black, and water rats. No major differences in acceptance of oat groat and cracked corn baits by species was indicated; therefore, acceptance of the Hawaiian bait was tested on cotton and black rats using larger numbers of animals. Cotton and black rats would be the targets of infield aerial bait application. Water rats were not included in this test because we believe that bait application at burrow entrances will be required for their control.

METHODS

Lethal Dose Determinations

Rats were trapped in sugarcane fields near Clewiston, Florida. They were individually caged in Gainesville, Florida and maintained on laboratory chow and water ad lib for one month before testing. Rats were fasted overnight prior to dosing. Predetermined, geometrically spaced doses were administered with a 2 cc syringe and balltipped needle, inserted via the esophagus into the stomach. An aqueous hydroxypropyl methylcellulose (Methocel®) system was used as the carrier for zinc phosphide.

For cotton and black rat determinations, 24 rats of each species were randomly assigned within sex to six dosage levels, such that two of each sex were dosed at each level. Six rats of each species were dosed with 2 cc of the Methocel® carrier only. In the water rat determination, nine males and one female were used. The female was assigned to the lowest dosage level; all others were randomly assigned to five dosage levels, yielding a total of two rats per level.

Median lethal doses (LD_{50}'s) were determined by the method of Weil (1952). Lethally-dosed rats were necropsied within 24 hours of death; survivors were killed and necropsied two weeks after test conclusion.

Bait Acceptance Tests

Rats were trapped near Clewiston, individually caged at Gainesville, and maintained on lab chow and water ad lib for six weeks prior to testing. Cages were kept in a controlled-environment chamber; lights adjusted to normal light cycle; 22 C, 80% humidity. Unconsumed foods were removed and fresh foods provided daily between 1000 and 1200.

Ten pounds each of oat groats and cracked corn were formulated as 96% carrier, 2% alcolec S (a lecithin adhesive) and 2% zinc phosphide (94% technical grade) by weight. Technical zinc phosphide concentration should have been 1.88%, but samples of the formulation analyzed at the Denver Wildlife Research Center had an average concentration of 1.67% technical zinc phosphide.

In Test 1, 8 rats of each species were provided with lab chow and either untreated oat groats (2 males and 2 females) or corn (2 males and 2 females) to determine if prebaiting might enhance consumption. Food was offered in separate 50 ml beakers, filled to the top (approximately 30 g). After receiving untreated bait carrier for 4 consecutive days, each rat received the same carrier treated with zinc phosphide for the next 4 days.

In Test 2, 8 rats of each species that had no (known) previous exposure to the bait carriers or zinc phosphide received either cracked corn (2 males and 2 females) or oat groats (2 males and 2 females) treated with zinc phosphide.

Consumption was determined daily by subtracting weighback of the remaining bait from the amount originally provided. In the case of many surviving rats we obtained negative consumption data, indicating weight gain of the remaining bait. We therefore assumed no consumption for negative values obtained on days 2 through 4 of the tests and used the mean of these values as a correction factor to be added to all consumption data. Consumption data should therefore be considered as estimates.

In Test 3, the light cycle was reversed, and rats were fed zinc phosphide-treated oats and untreated lab chow approximately 1 hour prior to the dark phase. It was hoped that this would reduce the potential for desultory nibbling of the bait with resultant aversion. Rats tested were increased to 27 cotton rats and 14 black rats.

Consumption data were obtained by counting spilled oats and estimating their weight from mean oat groat weight. Chewed or fractured oats were air-dried overnight and weighed; these values were added to the weights of bait remaining in the beaker, and the total subtracted from bait presented. Negative consumption values were again obtained for survivors. A significant correlation was found between these negative values and amount of bait spilled, indicating that mean oat groat weight had been overestimated, resulting in underestimation of consumption. A linear regression of negative consumption values on amount spilled was determined by species. Correction factors were obtained from this regression and applied to each rat's consumption on days with food spillage.

RESULTS AND DISCUSSION

LD_{50} Determinations

LD_{50} determinations are summarized by species and sex in Table 1. The overlapping confidence intervals indicate that the differences between species are probably not significant.

Table 1. Zinc phosphide LD_{50}'s (mg/kg) by species and sex. Confidence intervals in parentheses.

Species	n	Sexes combined	n	o	n	♀
Cotton rats	24	33 (26-42)	12	28 (20-39)	12	39 (28-55)
Black rats	24	39 (32-46)	12	35[a]	12	42 (39-59)
Water rats		---	9	42 (21-80)[b]		---

[a] No confidence interval; $\sigma_f = 0$ (Weil 1952)

[b] The only female used was at the lowest dosage level, which was dropped in calculating the LD_{50}.

None of the control rats died. Most of the lethally-dosed cotton and black rats died within 24 hours; all died within 48 hours. Two of three lethally-dosed water rats (42 mg/kg) died within 24 hours, but the third (58 mg/kg) died 4 days after dosing.

None of the lethally-dosed rats showed gross pathological signs other than those probably related to treatment. Distension of the gall bladder, gas in the stomach, and distension of the duodenum, sometimes accompanied by hemorrhage, were the most frequently noted abnormalities. Survivors did not show signs of long-term treatment effects.

Bait Acceptance Tests 1 and 2

Table 2 shows mean consumption of treated baits for Test 1 and Test 2. These data reflect mean consumption using data only from the day of greatest consumption for individual rats. For cotton rats and water rats, this was unusually Day 1. No major differences were observed between oat groat and cracked corn acceptance. Table 3 reflects these data in terms of number of LD_{50}'s consumed on the day of greatest consumption and total mortality during Tests 1 and 2. Cotton rats generally consumed a greater number of LD_{50}'s than black or water rats. In only one instance was 100% mortality achieved (cotton rats/oat groats/no prebaiting). Mortality of black rats was low except in Test 1 (oat groats/prebaiting). Consumption by all three species was considered to be low. Black-tailed prairie dogs tested on a 2% zinc phosphide/oat groat bait consumed 3.6 - 7.9 LD_{50}'s on the first day, with 93% mortality (Tietjen 1976).

Table 2. Mean consumption on day of greatest consumption during Tests 1 and 2 (g bait/kg rat weight*). Ranges in parentheses.

Test/bait	Cotton rats	n	Black rats	n	Water rats	n
1/Corn	3.8 (0.8 - 7.1)	4	3.4 (0.8 - 6.2)	4	3.2 (1.6 - 4.1)	4
2/Corn	5.0 (0.0 - 6.9)	4	1.3 (0.8 - 1.6)	4	2.0 (0.2 - 3.3)	4
1/Oats	4.2 (2.2 - 7.6)	4	4.6 (2.4 - 7.7)	4	4.4 (1.0 - 6.7)	4
2/Oats	6.0 (3.3 - 9.2)	4	1.2 (0.0 - 2.2)	4	4.2 (0.5 - 9.8)	4

*Average rat weights: cotton rats - .160 kg; black rats - .213 kg; water rats - .276 kg. Individual rats weights were used to determine g/kg bait consumed per rat on day of greatest consumption; averages of these determinations are shown above.

Table 3. Mean LD_{50}'s consumed on day of greatest consumption and total mortality during Tests 1 and 2. Ranges in LD_{50}'s consumed in parentheses.

Test/bait	Cotton rats		Black rats		Water rats	
	LD_{50}'s	Deaths	LD_{50}'s	Deaths	LD_{50}'s	Deaths
1/Corn	2.0 (0.4-3.6)	3 of 4	1.4 (0.3-2.6)	1 of 4	1.3 (0.6-1.6)	3 of 4
2/Corn	2.5 (0.4-3.5)	2 of 4	0.5 (0.3-0.7)	1 of 4	0.8 (0.1-1.3)	3 of 4
1/Oats	2.1 (1.1-3.8)	2 of 4	2.0 (1.0-3.3)	3 of 4	1.8 (0.4-2.6)	3 of 4
2/Oats	3.1 (1.7-4.6)	4 of 4	0.5 (0.0-1.0)	0 of 4	1.7 (0.2-3.9)	3 of 4

Data from Tests 1 and 2 suggest that prebaiting may enhance acceptance of treated oat groats by black rats but not by cotton or water rats. However, consumption was low and observed differences could be due to experimental error.

Survivors of Test 1 showed dramatically decreased consumption of both bait carriers when zinc phosphide was applied, and dramatically increased consumption as soon as they were returned to untreated bait carriers (Fig. 1). Consumption of the alternate food, lab chow, was inversely proportional to corn and oat groat consumption (except by water rats during pretreatment). Clearly, the rats detected and avoided the zinc phosphide-treated baits even though corn and oats were generally preferred foods when untreated.

Test 3

The marginally acceptable mortality in cotton rats and low mortality in black rats obtained in Tests 1 and 2 were confirmed in Test 3. Of 27 cotton rats, 18 died (67%), while only 3 of 14 black rats (21%) were killed.

Overall consumption is shown in Table 4 in terms of g of bait/kg rat weight and LD_{50}'s consumed on the day of greatest consumption. Again, these values are considered to be low for both species. In contrast to the results of Test 2, black rat consumption was comparable to that of cotton rats despite the fact that cotton rat mortality was much higher. The lower black rat values in Test 2 may have resulted from the small sample size and normal variation in consumption. The change in feeding schedules, however, may have resulted in greater black rat consumption in Test 3.

Overlap occurs between estimated LD_{50}'s consumed by survivors and nonsurvivors, but in general, cotton rats that consumed over 1.4 LD_{50}'s and black rats that consumed over 2.5 LD_{50}'s died. Two black rats

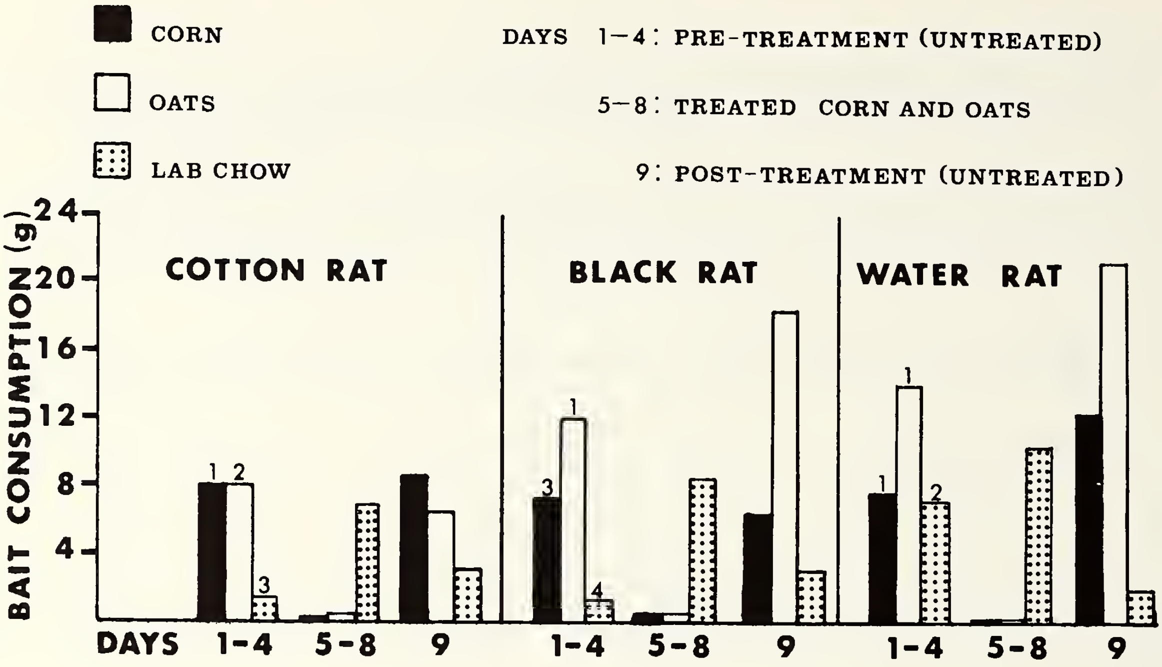

Fig.1. Consumption by survivors of Test 1. Rats received either corn or oats and untreated lab chow. Numbers over bars are the number of survivors used in consumption averages.

Fig. 1. Consumption by survivors of Test 1. Rats received either corn or oats and untreated lab chow. Numbers over bars are the number of survivors used in consumption averages.

Table 4. Mean consumption on day of greatest consumption during Test 3. Range is shown in parentheses.

	Cotton rat	Black rat
g/kg bait	4.1 (0.9 - 11.2)	4.2 (0 - 12.3)
LD_{50}'s	2.1 (0.4 - 5.6)	1.8 (0 - 5.2)

ingested very high quantities of bait (estimated 4.3 and 5.3 LD_{50}'s) and survived. Ingestion of bait does not necessarily guarantee ingestion of zinc phosphide. The toxicant was applied only to the surface of bait particles, and the amount adhering to individual particles may vary considerably. Some rats may have selectively consumed particles with less toxicant, or consumed only particle interiors. Handling of particles by the rats may also have removed some of the toxicant. Furthermore, the time period over which an acute toxicant is ingested is critical; nibbling of bait over a 24-hour period probably does not have the same effect as consumption of an equal quantity within an hour.

Because the consumption values of the forementioned black rats were so much higher than those of other survivors (the next highest value being about 2.6 LD_{50}'s), mean consumption data shown in Tables 5-6 were calculated including and excluding these two extreme values. Excluding these values brings black rat consumption down to a level comparable to that of cotton rats. Mean consumption on day of greatest consumption (Table 5) and mean total consumption (Table 6) by lethally-dosed rats did not differ greatly, indicating that lethal doses tended to be consumed within 24 hours. It should be noted that while LD_{50}'s consumed by lethally-dosed cotton and black rats were comparable, a much smaller proportion of black rats consumed lethal doses. There is considerable overlap in lethal and non-lethal doses, shown by the overlapping ranges in consumption.

Table 5. Mean consumption on day of greatest consumption during Test 3.

	Cotton rat			Black rat		
	n	$\bar{x}$ g/kg bait	$\bar{x}$ LD$_{50}$'s	n	$\bar{x}$ g/kg bait	$\bar{x}$ LD$_{50}$'s
Survivors	9	2.3 (0.9-5.1)	1.2 (0.4-2.6)	11[a]	3.9 (0-12.3)	1.7 (0-5.3)
				9[b]	2.3 (0-5.4)	1.0 (0-2.3)
Mortalities	18	5.0 (2.7-11.2)	2.5 (1.3-5.6)	3	5.2 (3.7-6.2)	2.2 (1.6-2.6)

[a] Two noneaters included
[b] Two extremely high values excluded

Table 6. Mean total consumption during Test 3.

	Cotton rat			Black rat		
	n	$\bar{x}$ g/kg	$\bar{x}$ LD$_{50}$'s	n	$\bar{x}$ g/kg	$\bar{x}$ LD$_{50}$'s
Survivors	9	3.1 (0.9-6.7)	1.6 (0.5-3.4)	11[a]	4.9 (0-13.7)	2.1 (0-5.9)
				9[b]	3.0 (0-6.4)	1.3 (0-2.8)
Mortalities	18	5.4 (2.5-14.4)	2.7 (1.3-7.3)	3	5.2 (3.7-6.2)	2.2 (1.6-2.6)

[a] Two noneaters included
[b] Two extremely high values excluded

CONCLUSIONS

Consumption was estimated more than determined, and serves as a relative index of zinc phosphide ingestion at best. In view of the overall low consumption, inaccuracy of consumption data alone may explain the highly variable response of rats to the baits. Results of this test indicate that the bait was only marginally effective on cotton rats and ineffective on black rats. Additional testing of the Hawaiian, as well as other, formulations is recommended prior to development of final conclusions as to acceptance.

Additionally, we feel that a small field test should be conducted with the oat groat bait to determine if large differences exist between field and laboratory mortality rates. Through the use of capture/recapture and telemetry data, rat populations could be indexed and mortality estimates obtained before and after treatment, and these indices compared with those from untreated fields.

ACKNOWLEDGMENTS

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EFFECTS OF HARVESTING SYSTEMS ON FIELD YIELD AND QUALITY OF SUGARCANE IN LOUISIANA[1]

B. L. Legendre
U. S. Sugar Cane Field Laboratory
Agricultural Research Service, USDA
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

ABSTRACT

Since the advent of whole-stalk mechanical harvesting in Louisiana, in 1938, the two problems of increased field loss (scrap) and increased trash have plagued harvesting efficiency. In an effort to improve this efficiency, especially in fields of above-average yield, two Australian models of cut-shop combine harvesters have been introduced into Louisiana since 1974. In five tests where one or the other combine harvester was compared with a conventional whole-stalk harvester, the combine harvester reduced apparent scrap losses by 44%, but increased trash percent cane by 27%. Of the total trash in the combined cane, field soil accounted for 20%, whereas, in cane harvested by the whole-stalk machine, field soil accounted for 12%. Furthermore, in three of the five tests, the sucrose content in the combined cane decreased by 10% and the purity by 3%, compared to cane harvested by whole-stalk harvesters.

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[1] Only the Abstract of the paper was available for the Proceedings.

THE HERITABILITY OF LODGING IN SUGARCANE[1]

P. M. Lyrene
Agricultural Research and Education Center
Belle Glade, Florida

ABSTRACT

The heritability of lodging was studied in 40 populations of space-planted sugarcane (Saccharum L.) stools. The populations consisted of 10 commercial cultivars, 25 populations of F_1 seedlings produced by crossing five of the cultivars as males with the other five used as females, and 5 S_1 populations obtained by selfing paternal parents. The test was planted in a randomized block experiment with one plot of each population in each of six blocks. A plot consisted of about 17 plants of a population spaced at 1 m intervals in a single row. Each plant in the test was given a lodging score ranging from 1 (fully erect) to 10 (fully prostrate). The purpose of the test was to determine the extent to which parental tendencies toward lodging or erectness are transmitted to F_1 and S_1 progenies. Lodging was much more severe in F_1 and S_1 populations than in parental clones. Lodging tendency was transmitted from parents to progeny; the correlation between midparent and F_1 lodging was 0.59. General combining ability effects for lodging were highly significant, but the estimate for specific combining ability was zero. F_1 populations with high stalk number per stool lodged more severely than those with fewer stalks, but lodging was not correlated with stalk diameter or stalk length. Extent of lodging had high heritability, as did stalk number per stool, stalk diameter, and flowering percent. Stalk length had low heritability and heritability of brix was intermediate. It was concluded that selection of upright parents should increase F_1 seedling erectness. In selection for erectness in a breeding program, uprooting should be considered a more serious defect than stalk bending.

INTRODUCTION

Lodging in sugarcane may have several undesirable effects. It may seriously reduce juice quality (7). It may lead to higher trash content in mechanically harvested cane due to poor topping, or to losses of millable cane due to reduced harvester efficiency in lodged cane. Early lodging stimulates production of late tillers, and late tillers lower juice quality at harvest. Root lodging in Florida muck soils leaves cane roots highly vulnerable to heat damage in pre-harvest fires, and stools which lodge from the roots are frequently torn from the ground by harvesting machines. Both fire damage and harvester damage may lead to serious losses of stand and to lower ratoon yields.

Two aspects of lodging that have received attention in studies by sugarcane breeders are its heritability and its correlation with other traits. Heritability studies have attempted to answer two questions: First, how reliably does the extent of lodging in a clone in one test predict its extent of lodging in future tests and in commercial fields? This question is concerned with repeatability or broad-sense heritability and has been studied much more extensively than the second question: To what extent do erect parents give erect progeny and lodged parents lodged progeny? Answers to this question help breeders decide how strongly to emphasize erectness in choosing parents for crosses. Obviously, they would like to cross only erect parents, but that would prevent the use of parents excelling in traits like brix, stalk weight and stalk number.

In a study of the broadsense heritability of lodging in about 1000 sugarcane clones, Hebert and Henderson (3) found an average correlation of r = 0.33 between lodging in unreplicated single-stool plots and in 5-foot clonal plots. Repeatability was lower for lodging than for stalk diameter. Skinner (6) estimated lodging reistance in sugarcane clones by measuring the force required to move individual stalks through an angle of 16 degrees from the vertical. These estimates were correlated with observed field lodging. There were significant differences among the clones tested, and statistical calculations indicated that selection for lodging resistance in replicated trials would be as successful as selection for yield. Breaux (1) rated 95 random F_1 sugarcane clones for erectness in each of four stages of the Louisiana breeding program. Erectness in each stage was positively correlated with erectness in replicated yield tests.

Relationships between lodging in parental clones and lodging in their progenies have been noted by Hebert and Henderson (3) and by Viator and Henderson (8). Hebert and Henderson observed lodging in parents and F_1 progeny of seven crosses. Although they studied no erect X erect or nonerect X nonerect crosses, they still observed some correlation between parental erectness and the frequency of erect F_1 plants. In five of eight crosses studied by Viator and Henderson (8), average progeny erectness was intermediate between that of the two parents. In two crosses, the F_1 averaged less erect than the less erect of the two parents, and in one cross the F_1 was more erect than the more erect parent. Crosses involving any of the three erect parental cultivars (CP 52-68, CP 66-346, and CP 65-357) produced the highest percentage of erect segregates.

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[1] This work was done at the USDA Sugarcane Field Station, Canal Point, FL.

Estimates of correlation between lodging and other traits are useful because they indicate why some clones lodge more than others and suggest how selection for other traits is likely to affect lodging. Hebert and Henderson (3) noted a consistent tendency for clones with many stalks to lodge more than those with fewer stalks. They also noted a weaker correlation between large stalk diameter and increased lodging.

Breaux (1) found no important correlations between lodging and stalk number or diameter, but observed consistent tendencies for clones with tall stalks or heavy stalks to lodge severely. In Skinner's experiment (6), lodging was not correlated with stalk number, diameter, length, weight, or sugar content. Breaux (1) observed no correlation between erectness and fiber percent. In general, correlation studies have shown that high-tonnage clones tend to lodge more than low-tonnage types, but the relationship is not a close one.

Previous studies that attempted to explain differences in lodging in a series of seedling populations in terms of variations in the extent of lodging in the parent clones have been based on too few crosses to allow convincing generalizations. The purpose of this study was to examine the extent of lodging in 25 F_1 populations obtained by intercrossing 10 sugarcane clones in order to determine the relationship between lodging in the parental clones and lodging in seedling populations obtained from them.

MATERIALS AND METHODS

Twenty-five F_1 populations were produced by crossing five clones as females with five clones used as males (Table 1). The five paternal clones also were self-pollinated to produce five S_1 populations. The parents were complex Saccharum hybrids of the type used commercially in Florida and Louisiana. Because commercial sugarcane clones are highly heterozygous, the F_1 is a segregating generation.

Table 1. Mean lodging score in parental, F_1, and S_1 sugarcane populations.

	Parental clones	F_1's from clones	S_1's from clones
(females)			
CP 52-68	1.05 A*	2.88 A	
CP 68-1067	1.16 A	3.70 B	
NCo 310	1.32 A	4.05 B	
CP 61-37	1.49 A	5.76 C	
CP 62-374	3.61 B	5.40 C	
female averages	1.73	4.36	
(males)			
CP 66-346	1.07 A	4.00 AB	2.95 A
CP 57-614	1.33 A	4.74 C	3.68 AB
CP 63-588	1.52 A	4.40 BC	5.35 C
CP 57-526	1.52 A	3.60 A	2.97 A
CP 70-300	2.67 B	5.04 C	4.87 BC
male averages	1.62	4.36	3.96

*Within male and female groupings within columns, means not followed by a common letter differ at the 5% level according to Duncan's Multiple Range Test.

In January 1975, F_1 seeds from each of the 25 crosses and S_1 seeds from each of the five paternal parents were planted in greenhouse flats. At the same time, a clonal population from each of the 10 parents was started from vegetative propagules in greenhouse flats. Vegetative propagules consisted of small wedges cut from the nodes of mature stalks so that each bore a shoot bud and a number of root primordia. Established plants were transplanted from germination flats to peat pots in March. On April 26 they were planted in a field on the USDA Sugarcane Field Station, Canal Point, Florida. Parents and seedlings did not differ visually in size or vigor at the time of transplanting. The experimental design was a randomized complete block replicated six times. Each block contained 40 plots (25 F_1 populations, 10 clonal parent populations and 5 S_1 populations). The single-row plots were spaced 1.5 m apart and contained 17 plants spaced 1 m apart. The test was bordered on each side by a row of seedlings spaced at 0.5 m intervals.

The length of the tallest stalk in each stool was measured during the period 30 July to 1 August 1975. Stalk length was measured from the ground to the top visible dewlap.

Stalks were counted in each stool between 18 and 22 August. Except for a few dwarf stools in which all stalks were very short, only stalks in which the top visible dewlap was 0.5 m or more above the ground were counted.

Stalk diameters were determined for two random stalks per stool between 27 September and 3 October. A caliper was used and measurements were made midway between two nodes, perpendicular to buds, and about halfway between the ground and top visible dewlap.

Lodging was scored between 11 October and 18 October. Each stool in the test was given a lodging score between 1 and 10, a score of 1 indicating a completely upright stool, a score of 10 indicating a stool in which all stalks were completely prostrate, and intermediate scores being the approximate average score for all stalks in the stool.

Variances in lodging scores within each of the 40 populations were obtained for each replication and pooled over replications. The average within-population variance for all F_1 populations was obtained by pooling within-population variances for the 25 F_1 populations, and the analogous calculation was made for parent clonal populations. An estimate of the heritability of lodging was obtained from these variances with the formula h^2 = (variance within F_1 populations minus variance within parent clonal populations)/variance within F_1 populations.

Another heritability estimate was derived from variance components for male parents (σ^2_m), female parents (σ^2_f), male X female interaction (σ^2_{mf}), and error (σ^2_e) following analysis of variance of the 150 F_1 plots (25 crosses X 6 replications). The formula used was

$$h^2 = \frac{\sigma^2_g}{\sigma^2_g + \sigma^2_{mf} / m + \sigma^2_e / rm}$$

where σ^2_g = the average of σ^2_m and σ^2_f, m = the number of male parents, and r = the number of replications.

Narrow-sense heritability was estimated by regressing mean lodging scores of F_1 populations on mean midparent lodging scores (4) and by doubling the regressions of lodging scores in F_1 populations on lodging scores for each of the two parents. Analogous heritability estimates were obtained by using parent-progeny correlations rather than regressions (2).

Correlations between lodging score, stalk diameter, stalk length, and stalk number per stool were obtained using mean values for each trait for each of the 25 F_1 population. Thus each datum used in calculating a correlation coefficient was a mean based on approximately 100 plants.

RESULTS AND DISCUSSION

Lodging was much more severe in F_1 and S_1 populations than in parental populations (Table 1). In each of the 25 crosses, the mean lodging score of the F_1 population was higher than the mean score of the parent which lodged most severely (Table 2). In general, the most upright parent clones, CP 52-68, CP 68-1067, and CP 66-346 (Table 1) produced the most upright F_1 populations, and the most recumbent parents, CP 62-374 and CP 70-300, produced the most recumbent populations. CP 61-37, which was intermediate in lodging, produced F_1 populations that were less erect than would have been expected from parental data, and CP 57-526, also intermediate, produced F_1's that were more erect than might have been expected. S_1 populations were slightly more erect than F_1 populations, but much less erect than their parents.

The correlation between mean midparent lodging and mean F_1 lodging was 0.59 (Table 4) for the 25 crosses. The correlation between F_1 and female parents was 0.53, and that between F_1 and male parents was 0.26.

Stools within parent clones were much less variable in lodging score than were seedlings within F_1 and S_1 populations (Table 3). Variance within parent clones has no genetic component and provides an estimate of nongenetic variance among stools. Variance within F_1 populations contains both genetic and nongenetic components. The heritability estimate obtained by comparing the magnitudes of these variances was 0.84 (Table 4).

Variances among the 25 F_1 populations (Table 3) provide estimates of general combining ability, specific combining ability, and broad-sense heritability. Because the mean square for females X males was lower than error mean square, the variance component ($^2_{mf}$) estimating male X female interaction, must have been near zero. This means that the tendency of a male to transmit erectness or recumbence did not vary depending on which female it was crossed with. The relationship is, of course, reciprocal, and the words male and female could have been exchanged in the preceding statement. Variance components due to females ($\sigma^2_f = 23.7$) and males ($\sigma^2_m = 4.9$) were both significant. The error component, calculated as the population X replication interaction, was 23.5, about three times the size of within-plot variance in F_1 populations (Table 3). Broad-sense heritability estimated from σ^2_m, σ^2_f, σ^2_{mf}, and σ^2_e was 0.95 (Table 4).

Heritability was estimated earlier (5) for several other plant traits based on the same formulas and plants used to estimate the heritability of lodging. Although the various estimating procedures were not entirely consistent in ranking the traits from highest to lowest heritability, some traits were clearly more heritable than others, and lodging was one of the more heritable. Stalk length was least heritable, brix had rather low heritability, and diameter, stalk number per stool, and flowering percent were highly heritable.

Table 2. Mean lodging score in 25 F_1 populations and deviation of F_1 from midparent and from higher parent.

Cross	Mean lodging midparent	Mean lodging F_1	Deviation of F_1 from midparent	Deviation of F_1 from more-lodged parent
CP 52-68 X CP 66-346	1.06	2.08	1.02	1.01
CP 52-68 X CP 57-614	1.19	3.25	2.06	1.92
CP 52-68 X CP 63-588	1.29	2.87	1.58	1.35
CP 52-68 X CP 57-526	1.29	2.45	1.16	0.93
CP 52-68 X CP 70-300	1.86	3.76	1.90	1.09
CP 68-1067 X CP 66-346	1.12	4.07	2.95	2.91
CP 68-1067 X CP 57-614	1.25	3.93	2.68	2.60
CP 68-1067 X CP 63-588	1.34	3.34	2.00	1.82
CP 68-1067 X CP 57-526	1.34	2.84	1.50	1.32
CP 68-1067 X CP 70-300	1.92	4.35	2.43	1.68
NCo 310 X CP 66-346	1.19	3.60	2.45	2.28
NCo 310 X CP 57-614	1.33	4.48	3.15	3.15
NCo 310 X CP 63-588	1.42	4.54	3.12	3.02
NCo 310 X CP 57-526	1.42	2.76	1.34	1.24
NCo 310 X CP 70-300	2.00	4.85	2.85	2.18
CP 61-37 X CP 66-346	1.28	5.84	4.56	4.35
CP 61-37 X CP 57-614	1.41	6.14	4.73	4.65
CP 61-37 X CP 63-588	1.51	5.45	3.94	3.93
CP 61-37 X CP 57-526	1.51	5.08	3.57	3.56
CP 61-37 X CP 70-300	2.08	6.27	4.19	3.60
CP 62-374 X CP 66-346	2.34	4.43	2.09	0.82
CP 62-374 X CP 57-614	2.47	5.91	3.44	2.30
CP 62-374 X CP 63-588	2.57	5.82	3.25	2.21
CP 62-374 X CP 57-526	2.57	4.86	2.29	1.25
CP 62-374 X CP 70-300	3.14	5.99	2.85	2.38

Table 3. Analysis of variance for lodging in parental, F_1 and S_1 sugarcane populations.

Source	df	Mean squares Expected	Mean squares Observed
Replications	5		123.1
Populations	39		263.7
Groups (S_1's, clones, and F_1's)	2		2651.8
Among S_1 populations	4		123.6
Among parent clones	9		68.9
Among F_1 populations	24		161.0
females	4	$\sigma^2_e + r\sigma^2_{mf} + rm\sigma^2_f$	733.0
males	4	$\sigma^2_e + r\sigma^2_{mf} + rf\sigma^2_m$	168.8
females X males	16	$\sigma^2_e + r\sigma^2_{mf}$	16.0
Error (population X rep)	195	σ^2_e	23.5
Within F_1 populations	2200		7.2
Within S_1 populations	380		7.4
Within parent clones	875		1.2

Of three stalk traits examined (stalk diameter, stalk length, and stalk number per stool) only stalk number was significantly correlated with lodging severity in F_1 populations, and stools with many stalks had less lodging ($r = -0.43$ between lodging score and stalk number/stool, Table 5). There were slight tendencies for tall stalks and large-diameter stalks to be associated with low lodging, but correlation coefficients were not significant at the 5% level.

It appears from this study that selection for lodging resistance would be effective. In fact, the superior uprightness of parental clones compared to random progeny in this study suggests that the parents had themselves been selected for uprightness in the various breeding programs from which they were produced.

Plants may lodge in at least two ways. In root lodging, entire stools fall over, and some of the roots are exposed, though stalks may remain straight. On the other hand, stalks may bend at some point above the ground causing stools to lodge without uprooting. Stiff-stalked, large-barrelled canes may be more subject to uprooting and less subject to stalk bending than canes with limber stalks. Uprooting is more undesirable than stalk bending, because it is more likely to affect the ratoon crop, and because uprooted stools are harder to harvest than stools with stalks erect at the bottom and bent farther up. Most of the lodging in this experiment was due to stalk bending, though there was some uprooting.

Table 4. Estimates of heritability for stalk lodging.

Method of estimation	r or b[1/]	h^2
Correlation of progeny and parental means		
F_1 - male parent	0.26	0.52
F_1 - female parent	0.53**	1.06
F_1 - midparent	0.59**	0.59
Regression of progeny on parental means		
F_1 - male parent	0.58**	1.16
F_1 - female parent	0.69**	1.38
F_1 - midparent	1.32**	1.32
Comparison of with-population variance		
F_1 and parent clonal[2/]		0.84
Analysis of variance		
Variance components[3/]		0.95

[1/] Correlation or regression coefficients, each based on 25 pairs.

[2/] h^2 = (Variance among stools within F_1 populations minus variance among stools within parent clonal populations) divided by variance among stools within F_1 populations.

[3/] $$h^2 = \frac{\sigma_g^2}{\sigma_g^2 + \sigma_{mf}^2 / r + \sigma_e^2 / rm}$$

Breeding for resistance to lodging has some similarities to breeding for cold tolerance. If a hurricane or tornado strikes a canefield, cultivars most resistant to lodging may be little better than those with little resistance, and in a severe freeze, cold tolerance may have limited value. On the other hand, in a year lacking even moderate windstorms, canes resistant to lodging may again be no better than those with little resistance, just as cold tolerance may be of no value in a year without freezes. There are enough intermediate years, however, to make breeding worthwhile for both lodging resistance and cold tolerance.

Table 5. Correlations between lodging scores, stalk diameter, stalk length, and stalk number per stool in 25 F_1 sugarcane populations.

	Stalk		
	Diameter	Length	Number per stool
Lodging score	-0.13	-0.20	-0.43*
Stalk diameter		0.32	-0.49*
Stalk length			0.06

*Significant at .05.

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A SERIOUS LOOK AT TITRATABLE ACIDITY

F. A. Martin
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

INTRODUCTION

Climatologists generally agree that for the past 50 years man has enjoyed some of the best weather he has ever known (13). According to many climatologists, however, our climate and the consistency of our seasons can no longer be taken for granted. If these predictions come to pass, the Louisiana sugarcane industry will probably experience a greater frequency of early freezes that are severe enough to seriously damage parts of its crop.

If the Louisiana sugarcane industry is to cope with increases in early, crop damaging freezes, it must have means of assessing the amount of damage caused by the freeze and the subsequent deterioration that follows a freeze. Titratable acidity, despite the associated limitations (2, 7, 9, 10), has been traditionally used as a measure of sugarcane juice quality following a freeze (1).

The intent of this paper is to review the association of titratable acidity to post-freeze deterioration, and to examine how changes in technology has affected the methodology of determining titratable acidity.

BIOLOGY OF POST-FREEZE DETERIORATION

Sugarcane tissue, upon death, becomes an ideal medium for the growth of microorganisms. These microorganisms thrive on that portion of the stalk that is damaged or killed. One of the major factors affecting the post-freeze deterioration is the post-freeze weather (2, 3, 8, 11).

The microorganisms that have been associated with sugarcane ferment sugars and produce alcohol, organic acids and polysaccharides (gums and dextrans) (5, 6) (Fig. 1). Although increases in titratable acidity and soluble polysaccharides are partially associated (6, 10), it is the soluble polysaccharides that can escape clarification and retard sucrose crystallization (9). This raises the question of why is titratable acidity used in determining post-freeze quality (1) rather than soluble polysaccharides.

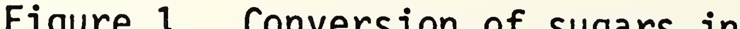

Fig. 1. Conversion of sugars in deteriorating sugarcane.

HISTORY OF TITRATABLE ACIDITY

Milling of sugarcane and production of granular sugar on a large scale in Louisiana date back to the end of the eighteenth century (4). At that time it was not known that dextrans and gums retard sucrose crystallization. It may be speculated that an observation that more lime was needed to neutralize deteriorated cane initiated the evolution of the use of titratable acidity to estimate deterioration of frozen sugarcane.

The procedure as stated by Meade (12) is to "pipet 10 ml of the juice into a porcelain dish or casserole, dilute with about 25 ml of water, which is neutral to phenolphthalein, add 2 to 3 drops of neutralized phenolphthalein solution and then run into the mixture, from a buret, N/10 NaOH solution until there is evidence of a pink color. Record the number of milliliters of the alkali used as the acidity of the juice."

It should be noted that this procedure was developed when cane was harvested entirely by hand. The cane, by today's standards, was free of mud, and the juice was relatively clear.

TECHNOLOGICAL CHANGES

Today virtually all cane in Louisiana is mechanically harvested. Inadvertently, trash and mud are delivered to the mills and the mill laboratory routinely gets dirty juice samples. This is particularly true when a core sampling system is used. With dirty samples it is humanly impossible to detect colorimetrically the endpoint of the phenolphthalein titration.

Modification of the procedure will be necessary if titratable acidity is to be estimated accurately with mechanically-harvested cane. Since it is not possible to detect a colorimetric endpoint, electrometric techniques will have to be used to detect the endpoint of titration. It should be emphasized that the pH meter would be used to determine the endpoint of titration, not the pH of the juice. The pH of the juice is a measure of effective acidity and not total acidity. The two are poorly associated (2, 9, 12).

It should also be noted that when a pH meter is used to determine the end-point of titration the procedure is simplified for there is no need to dilute the sample (Fig. 2). The reason for diluting the sample in colorimetric detection was to facilitate seeing the color change.

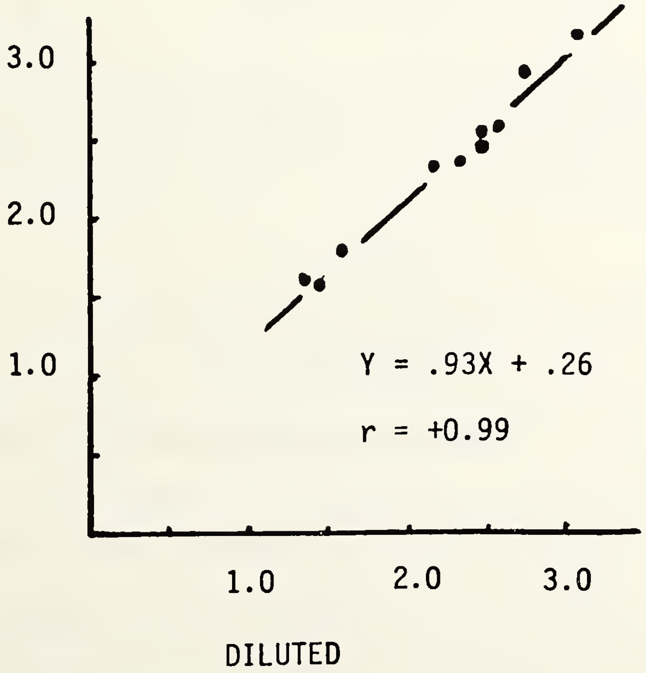

Fig. 2. Acidity of diluted vs. undiluted subsamples.

In a case where no pH meter is available one may be tempted to filter the sample before titration. This practice results in serious errors particularly when the levels of titratable acidity increases (Fig. 3).

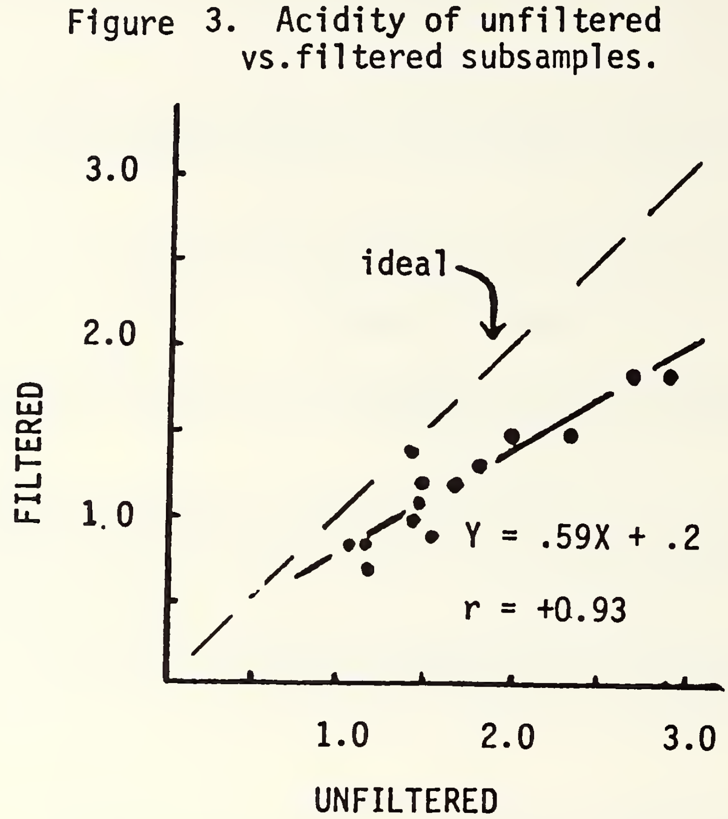

Fig. 3. Acidity of unfiltered vs. filtered subsamples.

The procedure of determining titratable acidity was developed for juice from roller mill extraction. As the Louisiana sugarcane industry converts to the core analysis system attention will have to be paid to the relationship between juice acidity of samples extracted by roller mills vs. prebreaker press of core samples (Fig. 4). This apparent lack of agreement should be further investigated. Also, future studies should determine the relationship between titratable acidity and the levels of gums plus dextrans for chipped and pressed samples.

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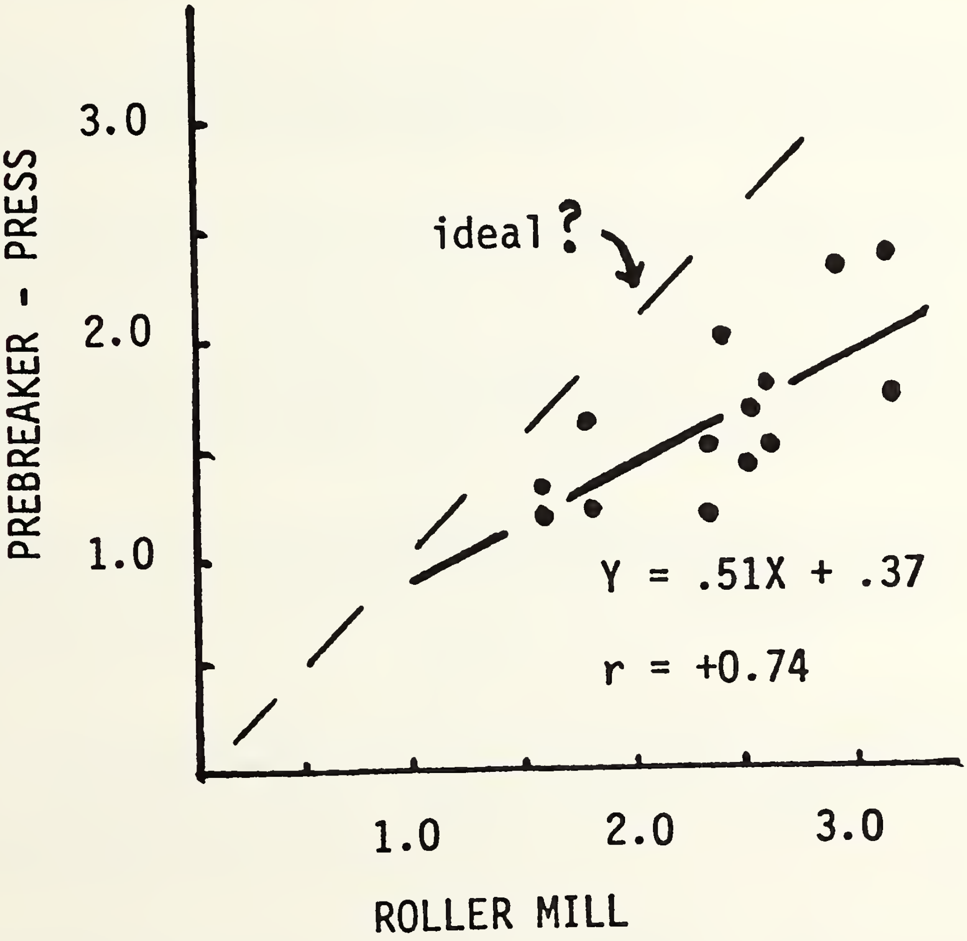

Fig. 4. Acidity of roller milled vs. prebreaker - pressed samples.

THE INFLUENCE OF ROW SPACING ON SUGARCANE STALK POPULATION, SUGAR CONTENT AND CANE YIELD[1]

R. J. Matherne and J. E. Irvine
U. S. Sugarcane Field Laboratory
ARS, USDA, Houma, LA 70361

ABSTRACT

The effect of row spacing on sugarcane yield was studied over a 10-year period. using row spacings from 12 to 84 inches apart. Plant population increased per unit of area as the interrow spacing decreased. Increases in plant population were very closely associated with increases in yield of cane. Interrow spacing that increased populations of millable stalks increased yield. Neither row spacing nor population was related to sugar content. Problems associated with changing row spacing in sugarcane plantations are discussed.

INTRODUCTION

Temperate zone sugarcane is characterized by slow early growth and a crop life of 8 to 10 months. Together with conventional wide row spacing and slow early growth, a short growing season promotes inefficient use of available land surface and light energy. Several attempts to improve this efficiency have been made.

On the conventional 6-ft interrow spacing common in Louisiana, increased stalk populations were strongly associated with increased yields of sugarcane varieties (5). However, simply planting more seed cane in the furrow failed to increase populations and yields (3, 6) unless diseased cane was used (8).

Populations and yields can be increased by planting rows closer together. This was first demonstrated in Louisiana by Stubbs in 1890 (9), and has been repeated there several times since (4, 6, 7), as well as in Argentina (2), Australia (1), and South Africa (10). In recent Louisiana tests comparing 3 and 6-ft row spacings, significant increases in population and yield were obtained with the closer row spacing (7). In 11 comparisons (four varieties), the average increase in yield was 25% with 3-ft row spacing. No decrease in concentration of sugar per ton of cane was observed. Although yield in plant cane with 3-ft rows was 50% greater than that obtained with 6-ft rows, the difference was not as great in stubble crops. This, and the difficulty of adapting 3-ft spacings to conventional farming practices, resulted in poor grower acceptance.

Grower acceptance seems more likely either if yields could be increased even more or if a spacing system could be devised that would be more compatible with existing practices. Research has progressed in both directions, culminating in very close spacing and in double-drill planting. This report summarizes 10 years of effort in row-spacing studies.

MATERIALS AND METHODS

Treatments and variables of row-spacing experiments are summarized in Table 1.

Table 1. Treatments and variables in row spacing experiments, Houma, La., 1967-1976.

Expt. No.	Interrow spacing	Year planted	Variety	Planting rate	Replications	Harvest data
	(in.)[2]			(No. stalks + 10% lap)		
1	36,42,72	1967	CP 61-37, CP 48-103	1.5,2	5	PC,1st,2nd[1]
2	36,42,72	1969	CP 61-37, L 60-25	2,3	4	PC,1st,2nd[1]
3	36,72,DD72-15	1970	CP 52-68	2	4	PC,1st,2nd
4	DD72-15,72	1971	CP 65-357	2,4	4	PC,1st,2nd
5	48,72	1072	CP 65-357, L 62-96	2,4	4	PC,1st

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[1] A contribution from ARS, USDA in cooperation with the Louisiana Agricultural Experiment Station.

Table 1. (Continued)

Expt. No.	Interrow spacing	Year planted	Variety	Planting rate	Replications	Harvest data
	(in.)[2/]			(No. stalks + 10% lap)		
6	DD84-30.72	1972	L 62-96	2,4	5	PC,1st,2nd
7	DD84-30, DD78-25,72	1074	CP 65-357	2,4	6	PC,1st
8	12,24,36,72 DD84-25	1974	CP 65-357	1 (2 for 72)	1	PC,1st

[1/] Some data from these experiments were previously published (Matherne, 1972; Matherne, 1973).
[2/] DD = double drill, DD72-15 is a double drill spacing with 72 inches between row centers and 15 inches between lines on the row.

In Experiments 1 to 7, cultivation and application of herbicides and an insecticide followed recommended practices for Louisiana. Fertilizer (anhydrous ammonia) application was limited to 150 lb of N/acre for each crop; soils in the experimental plots were classified as Mhoon silty clay loam. In Experiment 8, the field was leveled before planting and rows were opened in a flat field rather than in the customary raised bed. No cultivation was used and weeds were controlled by herbicides and shading. Fertilizer (ammonium nitrate) was applied at the rate of 200 lb of N/acre; the soil was classified as Sharkey clay.

In Experiments 1 to 7, plot sizes were of unequal area, depending on treatments. Lengths were uniform, and were generally 35 ft. Plot width varied with row width as the number of rows (3 to 5) was constant between treatments. In Experiment 8, the plot length was 120 ft and plot widths were 18 ft for the 6 ft spacing, 6 ft for 1-ft rows, 8 ft for 2-ft rows, 9 ft for 3-ft rows and 14 ft for double-drill rows.

In September of each year, millable stalks were counted, and height and size were measured. Plots were harvested at the normal time for plant and stubble crops. All cane in each plot was weighed to determine cane yields per acre, and 15-stalk samples were obtained for juice analysis, the determination of sugar per ton, and sugar per acre yields.

RESULTS AND DISCUSSION

Close row spacing did not affect the sucrose content of sugarcane in any of the tests. Samples were routinely taken for sucrose determination and analyzed in the standard manner, but in no test was there a significant effect of spacing on sucrose content. When sucrose values were paired with their respective population values, no significant correlation was found ($r = 0.08$, $n = 49$). These observations indicate that, with the varieties and conditions of these tests, closer row spacing did not result in a reduction in sugar per ton of cane.

Various double drill arrangements were included in over 20 harvests, and 17 of these are summarized in Table 2. The wide (84 in.) row allowed an approximate 30-inch spacing between drills on a raised bed. Yields were increased 4 to 21% (12 harvests) with this arrangement, but the wide row was incompatible with the use of conventional equipment and was especially difficult to harvest. Growers rejected this arrangement. Double drills on 72 or 78-inch rows (Table 2) gave yield increases of 3 to 31%. With flatter rows and 15 to 18 in. between drills, this arrangement can offer growers a cane yield increase of about 10% with minor equipment changes and no extra cost. Grower acceptance of this planting arrangement has been encouraging.

The intermediate spacings, 36 and 48 in., gave higher yield increases than did double-drill planting, with increases from 23 to 56%. Four 48-inch row spacing tests averaged 40 tons per acre (Table 2), and five 36-inch tests averaged nearly 50 tons per acre. We cannot visualize an approach that will allow 3 or 4-ft spacings to be adopted without major changes in cultivation and harvesting procedures. A compromise arrangement combining fixed traffic patterns on 6-ft rows between larger beds with 3 or 4-ft spacings may be successful.

The greatest yield increases shown in Table 3 were achieved with rows 1 and 2 ft apart. These yields were achieved in an unreplicated trial planting and no statistical interpretation can be made.

The close association of high yields with high populations is shown in Fig. 1. A highly significant correlation was found for the association between population and yield ($r = 0.96$, $n = 69$). The data for 1 and 2-ft spacings fit a linear regression line (Fig. 1). The association of higher yields with closer row spacing is also highly significant ($r = 0.68$, $n = 59$).

Table 2. Sugarcane yields in row spacing experiments.

Treatment and interrow space	Year planted	Yield of tons of cane per acre			
		Plant	1st stubble	2nd stubble	Average
(in.)					
CP 61-37	1969				
36[1]		50.6	43.7	43.7	46.0
42		44.2	35.9	40.7	40.3
72		32.5	28.2	36.1	32.3
LSD spacing		3.5	3.7	4.9	4.0
CP 65-357	1971				
2 stalks					
DD72-15		44.1	34.0	30.1	36.1
WD72-15		34.7	33.8	27.6	32.0
72		35.1	34.4	29.1	32.9
4 stalks					
DD72-15		48.1	35.4	31.9	37.8
WD72-15		42.7	35.7	28.8	35.7
72		39.0	33.9	29.8	34.2
LSD spacing		4.8	NS	NS	NS
LSD rates		2.8	NS	NS	3.6
CP 65-357	1972				
48		41.9	38.1	--	40.0
72		33.8	30.6	--	32.2
L 62-96	1972				
48		43.4	35.3	--	39.3
72		29.8	23.6	--	26.7
LSD spacing		3.4	3.9	--	3.7
L 62-96	1972				
2 stalks					
DD84-30		36.8	23.1	23.5	27.8
72		29.0	20.6	21.7	23.8
4 stalks					
DD84-30		37.0	24.9	24.5	28.8
72		30.4	22.6	23.6	25.5
LSD spacing		2.5	NS	NS	NS
LSD rates		NS	NS	NS	NS
CP 65-357	1974				
2 stalks					
DD84-30		43.7	44.4	--	44.0
DD78-25		40.7	43.5	--	42.1
72		33.3	41.3	--	37.3
4 stalks					
DD84-30		45.9	48.2	--	47.0
DD78-25		41.2	45.5	--	43.0
72		37.2	44.5	--	40.8
LSD spacing	1974	4.8	NS	--	5.5
LSD rates		3.6	2.6	--	3.1
CP 65-357	1974				
12		71.0	108.0	--	89.5
24		62.3	102.0	--	82.2
36		46.1	64.0	--	55.1
72		35.1	45.0	--	40.1
DD84-25		40.3	51.0	--	45.7

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[1] A single number (72) indicates distance between row centers in inches. The prefix DD indicates double drill, WD indicates wide drill. In complex numbers (72-15) the first number is the distance between row centers and the second is the distance between lines of cane on the row.

Table 3. Average yields and percent increases over standard 6-ft rows by close row spacing, Louisiana, 1967-1976.

Interrow spacing	Tons of cane/acre		Increase percent		Number of harvests
	Average	Range	Average	Range	
(in.)					
12	89.5	71-108	123	102-140	2
24	82.2	62-102	105	77-127	2
36	49.6	44-64	35	21-56	5
48	40.0	35-43	32	23-50	4
DD72	36.1	30-44	10	3-26	3
DD78	44.0	43-44	18	8-31	2
DD84	34.4	23-51	12	4-21	12

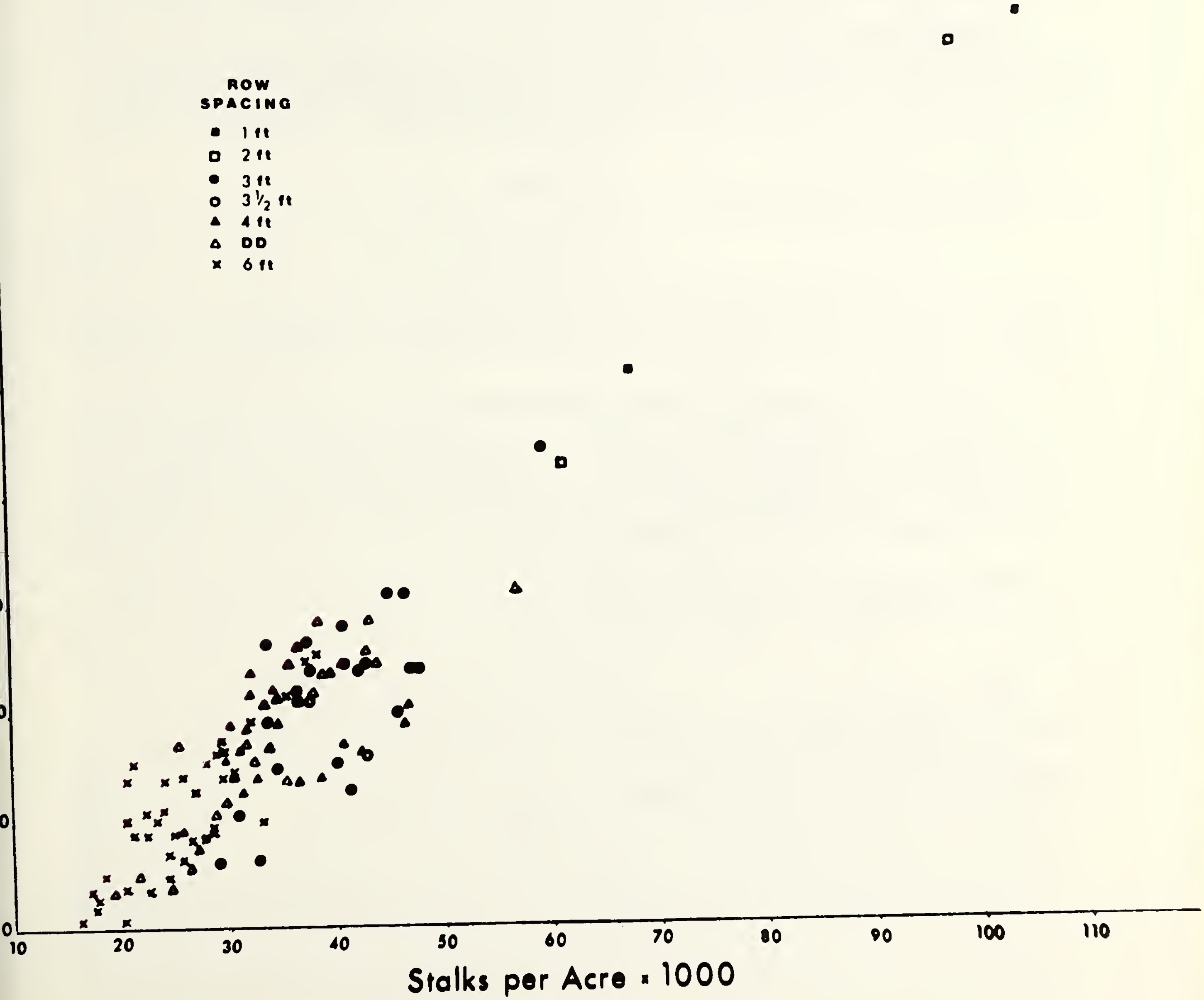

Fig. 1. Scatter diagram of the relationship between yield and stalk population.

Radical changes in farming practices would be necessary for the adoption of 1 or 2-ft interrow distances. Raised beds would have to be abandoned and flat culture used in order to make furrows deep enough to accommodate the seed cane. Preliminary trials have shown this this can be done with minor modification of existing row-crop equipment. The quantity of seed cane will have to be increased two to three times. Planted cane can be covered by one of several techniques. Fertilization can be accomplished by existing techniques, but the fertilization rate will probably have to be increased. Herbicides can be applied by conventional equipment, especially if wide spray booms and rigid traffic patterns are used to minimize breakage by ground equipment. Because of early shading, chemical weed control may be reduced. While the number of cultivations will be reduced, effective borer control will probably be more difficult.

Harvesting closely spaced cane remains the biggest unpredictable factor. On a per acre basis, harvesting costs increase as tonnage increases. Costs per ton of cane may decrease in the unlikely event that the soldier harvester system can be used for closely spaced cane. Should combine harvesters be required, harvesting costs per ton for closely spaced cane may double. If cane to be combined cannot be burned before harvest, ground losses (scrap) will increase and hauling costs will increase with increasing trash content. It is not known if closely spaced cane on flat culture can be harvested mechanically in wet weather. The effect of mechanical harvesting on stubbling ability of closely spaced cane will be unknown until tests have been harvested mechanically under varied conditions.

The increased cost of growing closely spaced cane (2-ft rows) has been projected as follows: cost of land preparation, seed cane and planting, up 98%; cost of cultural practices, down 6%; machine and truck maintenance, up 61%; cost of harvesting (combine harvesters), up 100%. Assuming no changes in the costs of supervision, management, road or building repair, overhead or miscellaneous costs, the increased cost per acre of producing closely spaced sugarcane can be estimated to be 37% more than cane on conventional 6-ft rows. The increased cost is less than the return from increased yield.

In summary, Louisiana farmers can expect a 10% yield increase with no additional cost by using double-drill planting. Greater yield increases may be attained through close spacings but major modifications in farm practices will be required.

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MATURITY TESTING OF SUGARCANE

J. D. Miller and N. I. James
USDA, ARS
Canal Point, Florida

and

Now USDA, ARS
Beltsville, Maryland

ABSTRACT

Six Florida commercial varieties were sampled biweekly from 26 August 1975 to 17 May 1976 for sucrose content, brix, and purity. Stalks were cut into three equal segments and hand refractometer brix was obtained at the midpoint of the segments. Segments were then milled to obtain laboratory analyses on crusher juice. These data were used to compare various maturity testing schemes. Brix at the midpoint of the stalk was a better indicator of sucrose content early in the season than top or bottom brix. After mid-January, brix of the different segments was not significantly different from whole-stalk brix. Data suggested that plotting bottom minus top brix provided a reasonably accurate indication of maturity status. Varieties were mature within 2 weeks of the time the difference in brix in the bottom minus top stalk segments equaled zero.

INTRODUCTION

The main purpose of maturity testing is to provide the grower with information to select fields for harvest that maximize total sugar production. The testing procedure that is adopted should be the one that provides adequate information at minimum cost.

Sugarcane accumulates sucrose from the base of the stalk to the top of the stalk (7) and is considered mature when sucrose is approximately equal throughout. Knowledge of average sucrose content in stalks does not necessarily indicate degree of maturity because of inherent differences among varieties in sucrose content at maturity.

Several maturity testing schemes have been proposed. Nath and Kasinath (5) considered sugarcane mature when top/bottom brix ratio approached unity. Doty (2) recommended sampling at the point on the stalk that reflects average sucrose content, usually one to three internodes above the mid-point. LeGrande and Martin (4) proposed using bottom minus top brix and bottom minus middle brix together and recommended harvest when the two indices approach zero. Waddell (6) suggested using the difference between brix at point 1/4 and point 3/4 from base to top of the millable stalk as an indication of the state of maturity. Smaller differences between upper and lower readings indicated greater degree of maturity. On the basis of cost and accuracy, Julien (3) concluded that hand refractometer brix at point 5/6 from the base to top was the best maturity-testing index.

This study was conducted to obtain information on sucrose accumulation patterns in six commercial varieties in Florida and to provide data for comparison of various maturity-testing schemes.

MATERIALS AND METHODS

Two-row plots 19.2 m long of six commercial varieties, CP 56-63, Cl 61-205, CP 56-59, CP 63-588, CP 57-603, and Cl 41-223, were planted in December, 1974. Rows were 1.6 m apart with 5 m between plots to reduce competition between varieties. There were two replications of each variety. A 10-stalk sample was collected from each replication at each of 20 biweekly sampling dates beginning 26 August 1975 and continuing through 17 May 1976. Stalks were cut at the base, topped at the top visible dewlap, hand stripped, and cut into three equal segments after removal of the soft joints at the top of the stalk. Top, middle, and bottom segments were weighed and juice samples were extracted from the center of stalk segments (i.e., points 1/6, 1/2, and 5/6 along the length of stalks from base) with a sampling punch for brix determination with a hand refractometer (Fig. 1). Stalk segments were crushed with a 3-roller sample mill and the primary juice from top, middle, and bottom segments was weighed separately. Spindle brix and pol were determined for juice from each segment. Whole-stalk data were calculated as weighted averages from segment data. The variety correction factors, as calculated by Arceneaux (1), were applied to determine the theoretically recoverable sugar in kg/tonne.

Correlation coefficients among characters were determined for each variety over all sampling dates and for each sampling date over all varieties.

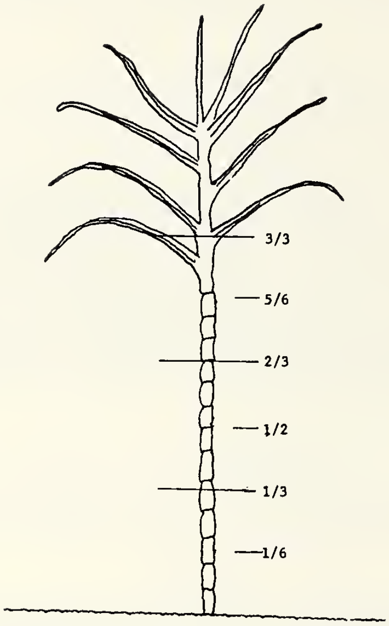

Fig. 1. Sugarcane stalk showing location of segments and points 1/6, 1/2, and 5/6 where hand refractometer brix was measured.

RESULTS AND DISCUSSION

Hand refractometer brix at the midpoint of the stalk was the best estimate of whole stalk brix early in the season (Table 1). By 12 January, the brix of the three segments was not significantly different from whole stalk brix, but the brix of the bottom segment tended to be closer to the brix of the whole stalk than brix of the middle or top segments. These data show that if brix is taken at only one point on the stalk to indicate sucrose content, it should be taken at the midpoint of the stalk early in the season, but may be taken at any point on the stalk later in the season.

Table 1. Whole stalk spindle brix and hand refractometer brix at midpoint of stalk segments on five dates averaged over six varieties.

Date	Whole stalk	Bottom	Middle	Top
Aug. 26	13.3b[1/]	16.4a	13.1b	6.6c
Nov. 4	17.2b	19.3a	18.8ab	12.9c
Jan. 12	19.8a	20.5a	20.8a	20.4a
Mar. 23	20.5a	20.4a	20.9a	21.4a
May 17	19.7a	19.5a	19.8a	20.7a

[1/] Means followed by a common letter are not significantly different (.05 level) according Duncan's multiple range test.

Table 2 shows the intensity of the correlation between recoverable sugar per ton and brix at various points in the cane stalks over all sampling dates for all varieties. Hand refractometer brix of the top segment was a better indicator of recoverable sugar per ton throughout the season than brix of either the bottom or middle segment. Except for variety CP 63-588, bottom minus top brix was a better indicator of recoverable sugar per ton than bottom minus middle brix or middle minus top brix. The relationship between spindle brix and recoverable sugar per ton was similar to the relationship between hand refractometer brix and recoverable sugar per ton, but the differences for the various segments were not as great for spindle brix. These correlations do not provide an indication of maturity status on a given day, but they do show a close relationship between brix of the stalk segments and recoverable sugar per ton throughout the harvest season.

Table 2. Correlation of sugar per ton with hand refractometer and spindle brix in stalk segments and difference in brix among stalk segments of six commercial varieties.

Character	Variety					
	CP 56-63	Cl 61-205	CP 63-588	CP 56-59	CP 57-603	Cl 41-223
Hand ref. brix						
Bottom	0.47	0.94	0.84	0.82	0.94	0.91
Middle	0.84	0.90	0.92	0.90	0.96	0.96
Top	0.91	0.94	0.96	0.96	0.97	0.96
Bot-Top	-0.83	-0.91	-0.71	-0.93	-0.94	-0.92
Bot-Mid	-0.68	-0.75	-0.60	-0.64	-0.84	-0.83
Mid -Top	-0.75	-0.85	-0.89	-0.91	-0.91	-0.86
Spindle brix						
Bottom	0.81	0.90	0.92	0.95	0.97	0.94
Middle	0.95	0.97	0.96	0.96	0.98	0.98
Top	0.91	0.96	0.98	0.98	0.98	0.97
Bot-Top	-0.83	-0.92	-0.94	-0.96	-0.93	-0.92
Bot-Mid	-0.83	-0.87	-0.87	-0.78	-0.90	-0.92
Mid-Top	-0.77	-0.83	-0.89	-0.93	-0.87	-0.80

Hand refractometer brix of top, middle, bottom, and bottom minus top, along with recoverable sugar per ton, are shown for three varieties at 20 sampling dates in Fig. 2, 3, and 4. These data show maturity status of each variety at each sampling date. By sampling 16 December, the brix of the three stalk segments of CP 56-63 were approximately equal, and the variety would be judged ready for harvest by several testing schemes (Fig. 2). There was some further increase in brix of top and middle segments which resulted in a small additional increase in recoverable sugar per ton. Also, increase in purity tended to lag increase in brix, so there was a small increase in recoverable sugar per ton due to further increase in purity (Table 3). By 9 March, a condition of over-ripeness was becoming evident and continued throughout the remainder of the sampling period. Recoverable sugar per ton decreased about 50 kg between 24 February and 17 May. Bottom brix minus top brix was a reasonably good indicator of maturity in this variety. Harvest could be recommended within 2 weeks after bottom minus top brix was zero.

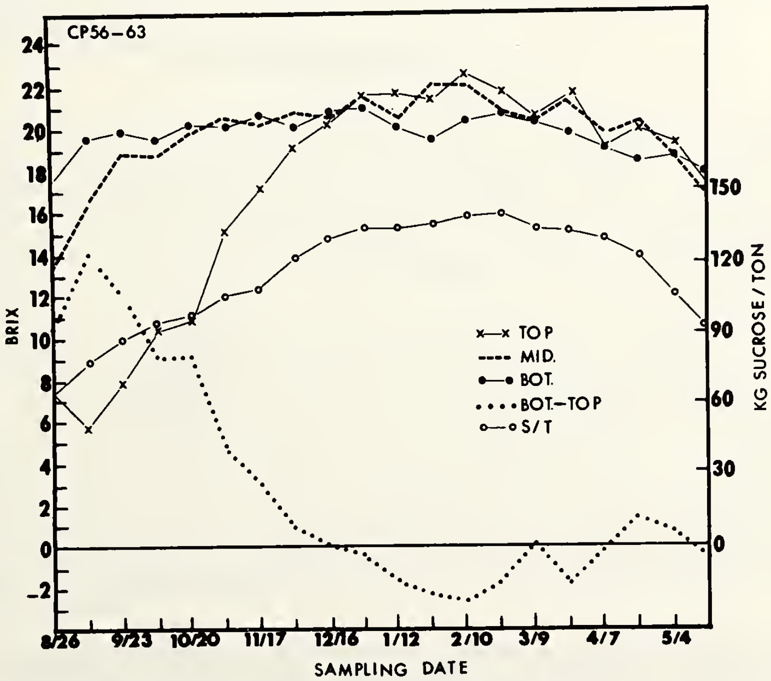

Fig. 2. Hand refractometer brix of bottom, middle, and top stalk segments, bottom brix minus top brix, and recoverable sugar/tonne of cane (kg/t) for CP 56-63.

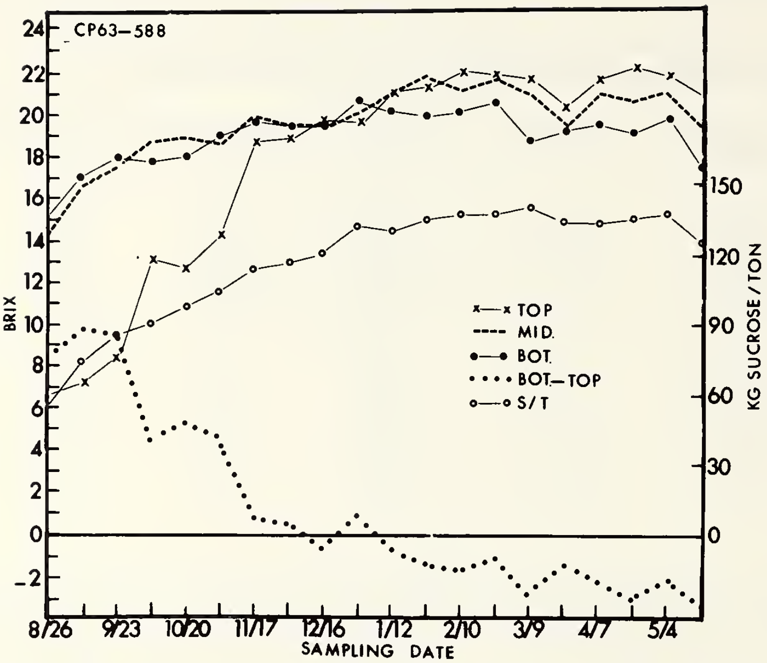

Fig. 3. Hand refractometer brix of bottom, middle, and top stalk segments, bottom brix minus top brix, and recoverable sugar/tonne of cane (kg/t) for CP 63-588.

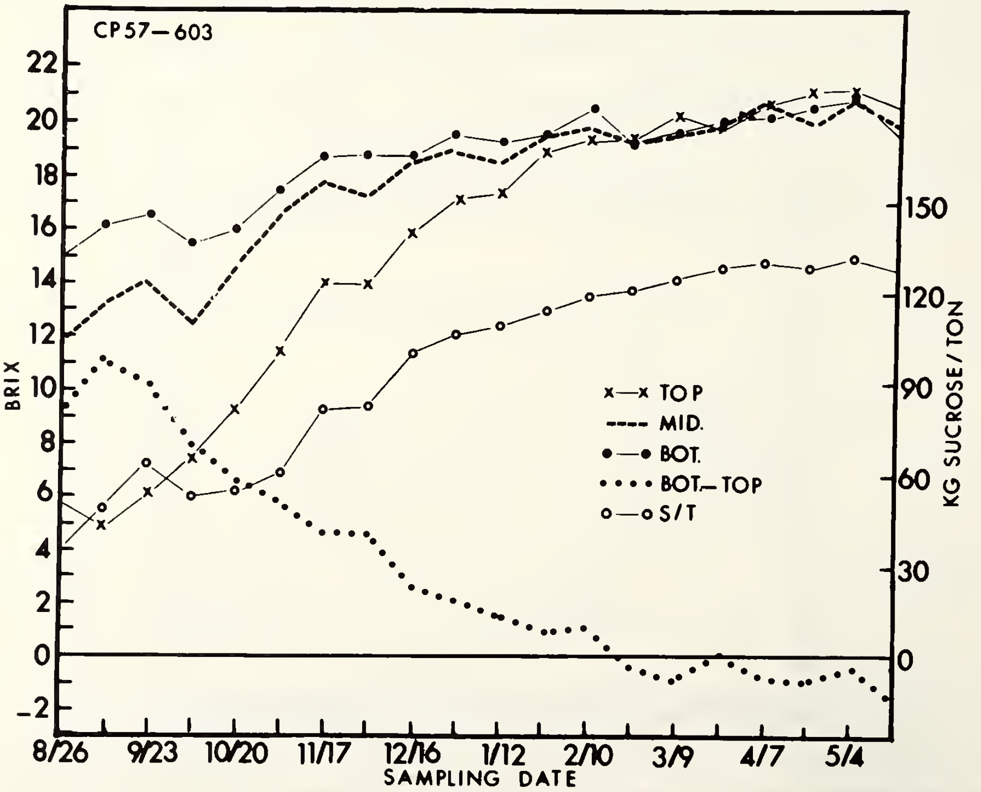

Fig. 4. Hand refractometer brix of bottom, middle, and top stalk segments, bottom brix minus top brix, and recoverable sugar/tonne of cane (kg/t) for CP 57-603.

Table 3. Purity of top and bottom segments of stalks of 3 sugarcane varieties at 20 biweekly sampling dates from 26 August 1975 to 17 May 1976.

Sampling date	Variety					
	CP 56-63		CP 63-588		CP 57-603	
	Bottom	Top	Bottom	Top	Bottom	Top
1	83.2	27.8	79.1	32.6	74.9	5.9
2	86.9	31.2	85.9	33.5	79.3	17.9
3	89.4	42.3	88.1	47.9	82.4	24.5
4	90.2	42.5	89.3	52.5	79.0	25.0
5	90.3	55.9	89.0	60.8	76.4	36.9
6	91.2	65.3	90.5	63.3	83.6	42.3
7	92.2	71.1	91.9	77.0	86.0	54.9
8	91.3	81.1	89.9	76.9	85.3	59.9
9	94.6	86.5	93.3	80.2	91.5	68.3
10	95.0	88.7	94.2	88.1	93.1	72.4
11	92.6	89.7	92.9	86.4	92.6	74.9
12	93.9	89.0	94.0	87.8	92.1	79.0
13	93.1	91.6	92.9	91.1	91.8	82.1
14	94.5	92.6	93.9	93.3	91.4	86.5
15	93.1	92.0	93.5	93.3	91.8	89.4
16	92.6	92.5	93.2	92.4	91.4	92.7
17	92.0	90.7	91.5	89.8	92.5	85.2
18	91.0	84.4	92.3	91.4	91.2	87.4
19	86.2	83.7	93.8	91.8	93.0	88.5
20	84.1	77.8	92.0	91.1	92.3	87.9

In variety CP 63-588, behavior of brix in the stalk segments was similar to variety CP 56-63 (Fig. 3). By 12 January, bottom minus top brix was a negative value and remained negative at all later sampling dates. CP 63-588 did not become over-ripe before 4 May and could be harvested with good results up to that time. The data from the 17 May sampling date were lower than those from pervious sampling dates and could be an indication of over-ripeness starting to occur in CP 63-588 (Fig. 3).

Brix values of top, middle, and bottom segments of CP 57-603, a late maturing variety, were equal on 24 February. Although recoverable sugar per ton continued to increase slightly, bottom minus top brix less than or equal to zero provided a reasonably accurate indication that maturity had been attained. This variety did not become over-ripe by the end of the sampling period.

CONCLUSIONS

Brix at the midpoint of the bottom stalk segment was highly correlated with recoverable sugar per ton. However, brix on a particular day at one point on the stalk is not a true indication of maturity because it does not indicate potential for additional sucrose storage. Difference in brix at the midpoints of the top and middle stalk segments does give an indication of maturity. When brix in the top and middle stalk segments is approximately equal, there is little potential for additional sucrose storage. A small additional increase in recoverable sugar per ton can be expected after bottom and top brix are equal because of the lag in purity as brix increases. Also, brix of top, middle, and bottom segments can increase slightly after brix has attained approximate equality in the three segments.

Determination of maturity status can be achieved with various methods. Periodic analysis of whole-stalk crusher juice obtained with a sample mill provides an indication of maturity over time primarily because increase in sucrose content of upper portions of the stalk results in increase of average sucrose content of the stalk. With this method, a variety would be judged mature when average sucrose content did not increase on successive sampling dates. Also, purity would be considered. Brix of the top segment of stalks and analyses of crusher juice from the top segment of stalks provide an indication of maturity over time. But none of the above methods provides a clear indication of maturity on a particular day. Brix at the midpoint of the top and middle stalk segments does provide an indication of maturity at the time of sampling. According to these data, a variety would be judged mature and ready for harvest within 2 weeks after brix was equal in the two segments. In our opinion, hand refractometer brix at the midpoint of the top and middle stalk segments is a reasonably satisfactory method of determining maturity considering cost and information obtained. Some periodic sampling would be required, depending on harvesting arrangements.

The usefulness of maturity testing to Florida sugarcane growers will be determined largely by constraints imposed by harvesting arrangements. For example, if a grower's harvesting arrangements are to harvest at three dates, the need for maturity testing may be limited to verifying expected maturity status of early, mid, and late season varieties. On the other hand, large growers who have the opportunity to harvest throughout the season can use maturity testing to select fields for harvest restricted only by cost of moving harvesting equipment.

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MATURITY OF SIX SUGARCANE VARIETIES IN FLORIDA

J. D. Miller and N. I. James
USDA, ARS
Canal Point, Florida
and
USDA, ARS
Beltsville, Maryland

ABSTRACT

Ten stalk samples of six sugarcane varieties were collected and milled for 20 biweekly intervals from 26 August through 17 May in the 1975-76 harvest season. Two early, two mid-season, and two late maturing varieties were chosen for a study of sucrose levels throughout the milling season.

Cl 61-205 and CP 56-63, the early maturing varieties, actually reached their maximum tons per hectare of cane (THC) about the first of November. However, they did not reach their maximum kg of sucrose per metric ton of cane (S/T) and tons per hectare of sucrose (THS) until the end of December. The two mid-season varieties, CP 63-588 and CP 56-59, reached their maximum THC in mid-October and maximum S/T and THS on 27 January and 24 February, respectively.

The two late varieties, CP 57-603 and Cl 41-223, reached maximum THC by mid-December and mid-January, respectively. Cl 41-223 reached its maximum S/T and THS in mid-April and mid-February, respectively. In contrast, CP 57-603 reached maximum S/T by mid-February but did not reach maximum THS until early-May.

INTRODUCTION

Sugarcane varieties that produce high sucrose levels early in the harvest season (late October and November in Florida) are commonly referred to as early maturing varieties. Actually, these varieties may not be mature when harvested, but may merely have a higher sucrose content than other varieties available for harvest at that time. A variety is mature when it has accumulated the maximum sucrose content possible under a given set of environmental conditions. Because of the five to six months harvest season in Florida, varieties are needed that mature at different times during the harvest season. Doty (3) indicated that if varieties were harvested in Florida when truly mature, profits would be increased by 10%.

Hebert and Rice (4, 5, 7) conducted maturity tests in Florida from 1 November through 1 March by segmenting stalks in thirds and comparing sugar level among segments. They concluded that if varieties had to be harvested before they were mature, a high percentage of the top segment should be removed when the cane is harvested. Varieties that mature at different times during the harvest season are used in most sugar-producing countries to provide high sucrose cane for the mill throughout the milling season.

Chinloy and Innes (2), working within one variety, determined that it was more efficient to sample stalks from several stools than to sample entire stools to determine cane maturity and which field should be harvested first. Lingerfelt et al. (6), working with whole stalk samples, determined the time varieties should be harvested to obtain maximum sucrose production.

The objectives of this experiment were 1) to study the relative differences in maturity of two early, two mid-season, and two late maturing sugarcane varieties, and 2) to estimate the amount of sucrose that could be produced with these varieties at different harvest dates.

MATERIALS AND METHODS

Two replications of each of six varieties (CP 56-63, Cl 61-205, CP 56-59, CP 63-588, CP 57-603, and Cl 41-223) were planted in two-row plots with two lines of cane per row in December, 1974. Rows were 1.6 m apart with plots 19.2 m long. Each two-row plot was separated from adjacent cane by at least 5 meters; thus, competition among varieties was minimal. Stalk number was recorded prior to the beginning of sampling in late August, 1975.

A 10-stalk sample was collected from each replicate at each of the 20 bi-weekly sampling dates starting on 26 August 1975. Samples were cut from one end of a plot, and all mature stalks were collected as they were approached down the row. Stalks were cut at the base, topped at the top visible dewlap, and hand stripped. Each sample was weighed and crushed in a three-roller sample mill with hydraulic pressure on the top roll. Cane yields per hectare (THC) were estimated by multiplying together the stalk numbers counted in August, the average stalk weights at each sampling date, and the appropriate area factors. A series of regression analyses based on successively higher order polynomial models was used to calculate prediction equations for THC until deviations from regression were no longer significant (8).

Brix was taken by spindle; pol was determined in an automatic polarimeter after clarification with dry lead sub-acetate. The variety correction factor (VCF) as modified by Arceneaux (1) was applied for each of these clones to determine theoretical recoverable sugar in kilograms per metric ton of cane (S/T). Yields per hectare of sucrose (THS) were estimated by multiplying the apparent sucrose content by the predicted yields from the regression curve for each variety at each sample date.

Data on S/T and THS were analyzed as a randomized block design with two replications at each of the 20 sampling dates. Data were analyzed within varieties, so the only comparisons that are valid are dates within a variety. Duncan's multiple range test was applied within each variety to determine significant differences in sucrose content.

RESULTS AND DISCUSSION

Mean estimates of cane yield (metric tons per hectare) for six varieties at each of the 20 sampling dates are presented in Fig. 1. The increase in cane tonnage from the initial sampling period until about 3 November was due primarily to continued growth of the cane. Most varieties had a period from early November to early April when little growth occurred. However, CP 56-59 started growing again in mid-January and increased in yield until mid-April. Most varieties resumed growth about mid-March. The growth rates (as measured by increasing cane tonnage) varied among varieties, with CP 63-588, CP 56-59, and CP 57-603 having the highest increase in cane tonnage in the spring. Three of the varieties, CP 56-63, Cl 61-205, Cl 41-223, produced approximately the same amount of cane at about 85 to 95 tons per hectare. The two mid-season varieties, CP 63-588 and CP 56-59, produced about 120 to 135 tons of cane per hectare on the average. CP 57-603 was the highest yielding variety of the six tested, producing about 150 tons of cane per hectare.

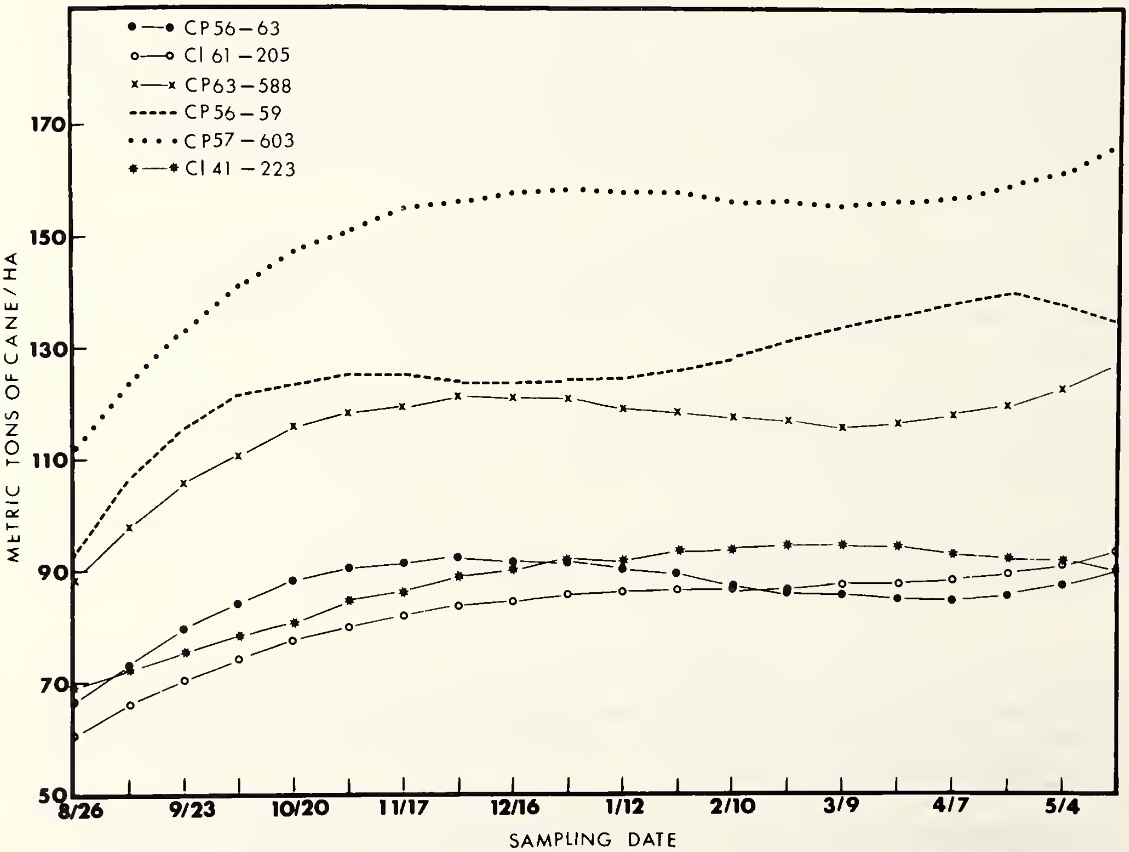

Figure 1. Yields of cane (t/ha) as estimated by regression equations for six varieties at each of 20 sampling dates.

Table 1. Regression equations for estimating cane yields for 6 varieties at 20 sampling dates.

Variety	Regression equation
CP 56-63	$Y = 57.212 + 10.455X - 0.847X^2 + 0.025X^3$
Cl 61-205	$Y = 53.797 + 7.069X - 0.516X^2 + 0.013X^3$
CP 63-588	$Y = 76.899 + 12.949X - 1.185X^2 + 0.033X^3$
CP 56-59	$Y = 74.350 + 22.726X - 3.525X^2 + 0.225X^3 - 0.005X^4$
CP 57-603	$Y = 97.000 + 15.700X - 1.306X^2 + 0.035X^3$
Cl 41-223	$Y = 64.186 + 4.238 - 0.148X^2$

Mean estimates of apparent sucrose content for six varieties at each of 20 sampling dates are shown in Table 2. Sucrose content was much less variable than stalk weight; therefore, apparent sucrose values were much less variable than cane yield estimates. Early maturing varieties are usually harvested from late October to early December. However, as shown in Table 2, the "early maturing varieties" were not mature before the end of December, although they were higher in sucrose than other available varieties in October and November. Mid-season maturing varieties usually are harvested in December and January, but these data indicate that neither CP 63-588 nor CP 56-59 was mature before the end of January. The late maturing varieties, CP 57-603 and Cl 41-223, were mature by the first week in February. Therefore, there was little actual difference in time of maturity of the mid-season and late maturing varieties in this test.

Table 2. Mean estimates of apparent sucrose content (kg per metric ton) of 6 varieties at each of 20 sampling dates.

Sampling date	Varieties					
	CP 56-63	Cl 61-205	CP 63-588	CP 56-59	CP 57-603	Cl 41-223
Aug. 26	65.01 h*	61.20 i	54.60 k	54.06 l	36.50 i	51.42 i
Sept. 9	78.71 g	82.98 h	73.86 j	62.87 k	52.56 h	62.80 h
23	87.59 fg	90.52 gh	86.33 i	79.63 ij	66.77 gh	68.23 h
Oct. 7	94.79 ef	99.56 fg	90.66 i	78.40 j	56.29 h	75.97 g
20	100.85 cdef	104.35 ef	98.10 h	85.14 hi	58.43 h	81.73 g
Nov. 4	107.14 cde	112.14 e	104.10 h	90.61 gh	74.88 fg	92.00 f
17	110.60 c	122.11 d	113.88 g	94.47 g	85.29 f	97.19 f
Dec. 2	124.02 b	128.82 cd	116.41 fg	103.31 f	85.98 f	105.65 e
16	131.66 ab	134.98 bc	122.15 ef	113.91 e	105.57 e	120.30 d
30	137.75 ab	141.37 ab	132.40 bcd	120.51 d	111.97 de	128.65 c
Jan. 12	136.75 ab	142.09 ab	131.04 cd	120.11 de	114.95 cde	131.02 bc
27	138.20 ab	141.80 ab	136.01 abc	122.15 cd	119.11 bcde	128.77 c
Feb. 10	140.92 a	145.14 ab	138.64 abc	126.43 abcd	124.48 abcd	133.35 abc
24	141.15 a	144.92 ab	139.94 ab	130.44 a	125.79 abcd	134.57 abc
Mar. 9	136.57 ab	148.99 a	141.25 a	129.25 ab	130.58 abc	135.59 abc
23	136.85 ab	145.99 a	136.63 abc	130.53 a	133.86 ab	135.75 abc
Apr. 7	135.25 ab	145.15 ab	136.87 abc	128.08 abc	135.08 ab	137.95 ab
20	125.49 b	146.03 a	138.60 abc	122.78 bcd	134.77 ab	139.01 a
May 4	108.80 cd	145.57 ab	140.09 ab	129.02 abc	139.83 a	133.88 abc
17	95.34 def	145.79 a	127.50 de	126.38 abcd	134.59 ab	140.63 a

*Means within a column followed by a common letter are not significantly different (5% level) according to Duncan's multiple range test.

If sugarcane is harvested too long after maximum sucrose content has been attained, a loss of sucrose may occur. In this test, over-ripeness occurred in CP 56-63. Optimum harvest time for CP 56-63 was 16 December to 7 April. After that time, the amount of recoverable sucrose decreased markedly. Over-ripeness also occurred in CP 63-588 on the 17 May sampling date. The other varieties tested maintained their sucrose level through the 17 May sampling date. Cl 61-205 had the highest sucrose content at maturity in this experiment. When CP 56-63, CP 63-588, CP 57-603 and Cl 41-223 were mature, they contained about 5 to 10 kg less sucrose than Cl 61-205. CP 56-59 had the lowest sucrose content at maturity of the varieties tested.

The optimum time to harvest the varieties tested based on maturity would be as follows: CP 56-63 between 16 December and 7 April, Cl 61-205 between 30 December and 17 May, CP 63-588 between 27 January and 4 May, CP 56-69, CP 57-603, and Cl 41-223 between 10 February and 17 May.

Estimated yields of apparent sucrose of six varieties at each of 20 sampling dates are presented in Fig. 2. The data in Fig. 2 are the product of tons of cane per hectare times kg apparent sucrose per ton of cane. These values show that CP 56-63, Cl 61-205, Cl 41-223, and CP 63-588 reached their maximum yields by 30 December. CP 56-59 which has been classified as a mid-season variety did not produce maximum sucrose until mid-March. The late maturing variety, CP 57-603, continued to increase in THS throughout the sampling period.

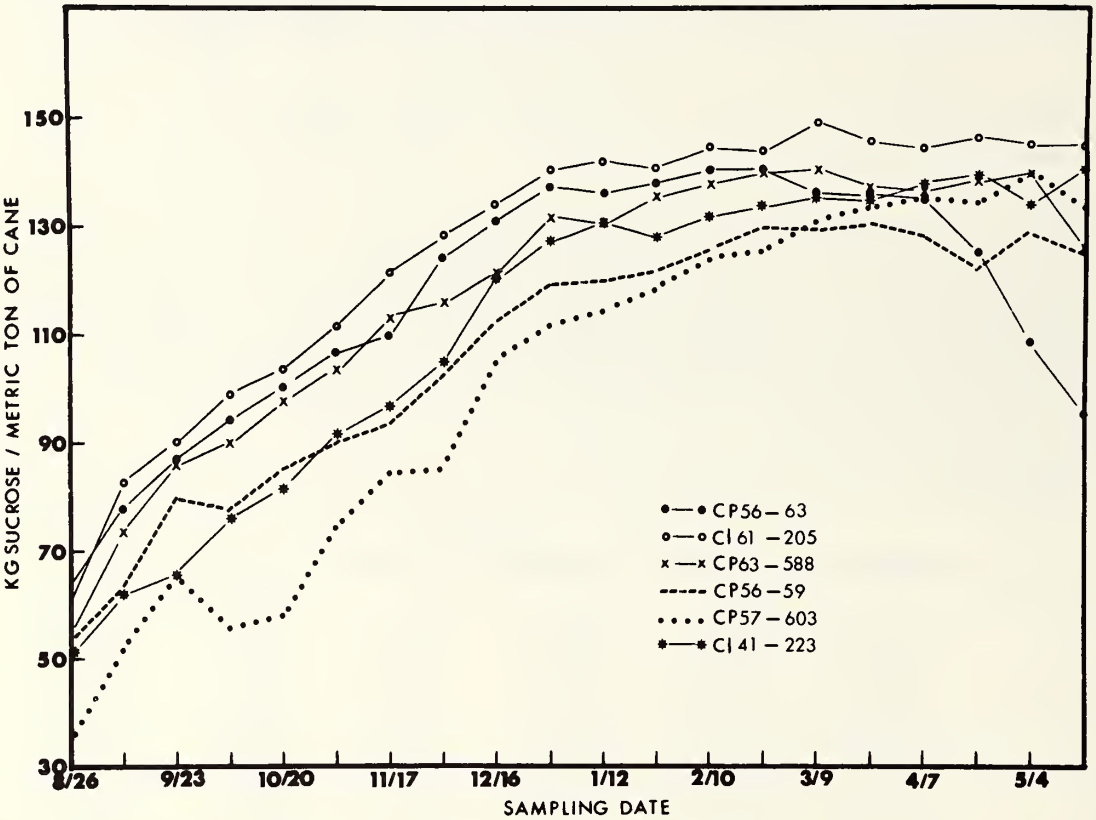

Figure 2. Yields of sucrose (kg/ha) for six varieties at each of 20 sampling dates.

The maximum sucrose yield is seldom obtained from early maturing varieties. They are utilized primarily to start the mill in late October and November because they have a higher sucrose content than other varieties at that time. For example, on 4 November CP 56-63 and Cl 61-205 both produced less sugar per hectare than did CP 63-588, CP 56-59 and CP 57-603. However, the latter three varieties may not be as desirable for milling because of their lower sucrose contents at this time. By 12 January, the relative differences in sucrose content among varieties was not as important because even CP 57-603, the variety with the lowest sucrose content on that date, contained 115 kg/t. These differences are reflected in Fig. 2 which shows that the two early maturing varieties with reduced tonnages produced less than 12,000 kg/ha of sucrose on 12 January, while the two mid-season varieties produced at least 2,000 kg per hectare more sugar, and CP 57-603, the variety with the lowest sucrose content at this date, produced almost 6,500 kg/ha more sucrose than did the two early maturing varieties. At this date, Cl 41-223 produced approximately the same amount of sucrose per hectare as did the early maturing varieties. Two months later, on 9 March, the early maturing varieties were still producing about 12,000 kg of sucrose per hectare while the mid-season and late maturing varieties had continued to increase in sucrose content. By that time, CP 56-59 was producing about 4,500 kg of sucrose per hectare more than the two early maturing varieties while CP 63-588 and CP 57-603 were producing approximately 6,000 kg per hectare more. The maximum sugar per hectare in this experiment was produced by harvesting CP 57-603 on 4 May.

These data show that even though a cane produces high sucrose content or high tonnage, either of these factors alone may not be enough to justify planting a variety. Rather, the factors to be considered in choosing varieties for commercial planting are: 1) sucrose concentration at the anticipated harvest date, 2) potential THS yields available with the variety, and 3) the number of hectares of the variety needed to supply a given mill quota.

ACKNOWLEDGMENT

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FLAME CULTIVATION COMPARED WITH MSMA FOR CONTROL OF ITCHGRASS (*ROTTBOELLIA EXALTATA*) IN SUGARCANE[1]

R. W. Millhollon
Science and Education Administration, USDA
Houma, Louisiana 70361

ABSTRACT

A flame cultivator utilizing commercial flat burners and propane fuel was used in sugarcane (*Saccharum* interspecific hybrids) to flame either a 24-in. band over the sugarcane drill or, after the last cultivation, a 60-in. area over the entire row. Operating the flame cultivator at 3 mph with a 40 psi gas pressure to the burners was judged one of the better combinations of speed and pressure for effective itchgrass control and safety to sugarcane. Flame provided about 88% control of itchgrass about 4 inches tall, whereas monosodium methanearsonate (MSMA) at 2.5 or 3.5 lb/A provided about 99% control. Sugarcane yields were not reduced significantly below the yield of a hoed check by either the flame or MSMA treatments.

INTRODUCTION

Itchgrass is a severe weed pest of sugarcane in Louisiana because it germinated periodically throughout the growing season, competes intensively with sugarcane, and is not controlled effectively by many of the available herbicides (2, 4). The organic arsenicals, including MSMA, are highly effective as foliar treatments for the control of large or small itchgrass plants (2). MSMA has also been effective for selective control of rhizomatous johnsongrass (*Sorghum halepense* (L.) Pers.) in sugarcane (3). However, as of January 1, 1978, MSMA was not registered by the Environmental Protection Agency for use in sugarcane.

Flame cultivation is commonly used in many crops to control weeds and it has been used experimentally to control johnsongrass in sugarcane (1). The development of the flat burner, which utilizes liquefied petroleum (L-P) gases and produces a relatively short, flat flame that stays near the surface, has greatly extended the use of the flame cultivator (5). Traditionally, however, flame cultivation has not been used extensively for weed control in sugarcane.

In this study flame cultivation was compared with MSMA treatments to determine the feasibility of using flame to control itchgrass in sugarcane.

MATERIALS AND METHODS

For the flame treatments a commercial flame cultivator equipped with AFCO burners was mounted on a high-clearance tractor. The burners were of the flat, self-vaporizing, venturi type. Propane was used as fuel with gas pressure to the burners controlled with a pressure regulator and pressure gauge. Cross flaming was utilized to flame a 24-in. band over the sugarcane drill by placing one burner on each side of the row with the fire aperture of the burner about 6 in. above and at a 45° angle to the top of the bed and about 14 inches from the sugarcane shoots. The burners were staggered to prevent clashing of the flame from opposite burners. To flame the entire row about 60 in. wide, two additional burners, making a total of 6 burners per row, were placed parallel to the row on each side of the bed. These parallel burners faced to the rear of the cultivator at a 45° angle to the sides of the bed.

Field experiments were conducted on cultivar CP 52-68 sugarcane on silt loam near Houma, Louisiana in 1965 and at Breaux Bridge, Louisiana in 1966. Both sites were heavily infested with itchgrass.

The first field experiment was a non-replicated study to determine the general characteristics of the flame cultivator in controlling itchgrass and injury to sugarcane. The flame cultivator was operated at 2 or 3 mph and at gas pressures to the burners of 15 to 40 psi.

In the second field experiment all plots including the check were treated in March and again in April with a standard preemergence treatment of a mixture of the sodium salt of trichloroacetic acid (TCA) at 10 lb/A and 2-(2,4,5-trichlorophenoxy) propionic acid silvex) at 3 lb/A. Postemergence treatments with flame or MSMA were then applied as needed whenever itchgrass was about 4 in. tall.

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[1] Cooperative investigations of Sci. and Ed. Admin., U. S. Dept. of Agric., and the Louisiana Agric. Exp. Sta.

The postemergence treatments were arranged in a split-plot design with subplots (17 x 45 ft) in randomized complete blocks with 5 replicates. Hoed (weed-free) and nonhoed treatments were assigned to whole plots. Subplots were treated with MSMA at 2.5 or 3.5 lb/A or flamed at speeds of 2 or 3 mph. Before lay-by (last cultivation), treatments were applied to a 24-in. band over the drill and the remainder of the row was cultivated as needed to control weeds. After lay-by, MSMA and flame were applied to the entire row. A 0.5% nonionic surfactant was added to the MSMA solutions. Water at 40 gal/A was the iluent for all herbicidal sprays.

RESULTS AND DISCUSSION

Table 1 shows the general interrelationships among tractor speed, gas pressure to the burners, and number of consecutive flame treatments in controlling itchgrass and injury to sugarcane. Control of itchgrass at either 2 or 3 mph increased as gas pressure increased from 15 to 40 psi. Increasing pressure primarily increases the total amount of heat output rather than increasing the temperature. At the 40 psi pressure, a speed of 2 mph gave slightly better itchgrass control than a speed of 3 mph, but the slower speed also caused more injury to the sugarcane. Dual flame treatments were more injurious to sugarcane than single flame treatments, particularly at the 40 psi pressure. Based on these results, we used the 40 psi pressure and single flame applications at both the 2 and 3 mph speeds for further study in the second experiment.

Table 1. Effect of flame-cultivator calibration and number of consecutive treatments on control of itchgrass about 4 in. tall and injury to sugarcane.

Flame-cultivator variables		Times treated	Itchgrass control	No. sugarcane leaves severely injured
Speed (mph)	Gas pressure (psi)	(No.)	(%)	(% of total no.)
2	15	1	90	7
2	15	2	90	25
3	15	1	60	4
3	15	2	80	7
2	25	1	92	28
2	25	2	100	45
3	25	1	65	28
3	25	2	85	35
2	40	1	100	55
2	40	2	100	75
3	40	1	90	30
3	40	2	99	65

In the second field experiment the preemergence treatments with TCA-silvex controlled itchgrass until May 27 when further control was needed. Both MSMA and flame initially applied on May 27 and reapplied to a new infestation on July 15 controlled itchgrass effectively (Table 2). MSMA gave almost perfect control at both 2.5 and 3.5 lb/A. I have observed that the 3.5 lb/A rate is generally more effective than the 2.5 lb/A rate when treatments are made earlier in the spring because temperatures are colder and itchgrass growth is slower. Flame treatments gave 84 to 90% control or about 10 to 15% less control than the MSMA treatments. Flame did not control some of the larger weeds and was most effective on weeds 2 to 3 in. tall. The flame cultivator was as effective at 3 mph as at 2 mph and the higher speed would reduce the operating cost.

Table 2. Control of itchgrass with postemergence applications of MSMA and flame.

Treatment	Itchgrass control after treatment on: May 27 (%)	July 15 (%)
MSMA - 2.5 lb/A	100	99
MSMA - 3.5 lb/A	100	99
Flame - 3 mph	88	87
Flame - 2 mph	84	90
None	0[1]	0[2]

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[1] Itchgrass infestation on the 24-inch treated band was 42 plants/100 sq. ft.

[2] Itchgrass infestation on the 5-foot width of treated row was 12 plants/100 sq. ft.

The MSMA and flame treatments did not significantly affect the yield of sugarcane as shown by the yields in plots that were also hoed to maintain them weed-free (Table 3). These treatments, however, did not increase yields in the nonhoed plots. The early season control of itchgrass by preemergence treatments apparently delayed weed competition long enough to prevent a loss in yield. Even though the late-germinating itchgrass did not affect yields, control of these plants was needed to prevent the production of new seed.

Table 3. Yield of sugarcane as affected by MSMA and flame in combination with hoeing treatments.

Herbicide or flame treatment	Yield[1] by hoeing treatment		Mean yield[1] (T/A)
	None (T/A)	Hoed[2] (T/A)	
MSMA - 2.5 lb/A	26	26	26
MSMA - 3.5 lb/A	26	25	26
Flame - 3 mph	27	27	27
Flame - 2 mph	27	26	27
None	27	27	27
Mean[1]	27	26	

[1] Yields were not significantly different at the 5% level of significance as determined by an analysis of variance.

[2] Plots maintained weed-free throughout the growing season.

Fuel is the primary expense in operating a flame cultivator, and the price of propane has increased substantially in recent years. If cost of propane is $0.50/gal, and 3 to 4 gal/A of propane are needed to flame a 24-in. band (2 burners per 6-ft row), the fuel cost for flaming would be $1.50 to $2.00/A per treatment. At this cost, flame cultivation compares favorably with the cost of herbicides that could be used to provide a similar degree of control.

ACKNOWLEDGMENTS

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CONTROLLING ASTER LATERIFLORUS IN SUGARCANE[1]

R. W. Millhollon
U. S. Sugarcane Field Laboratory
Agricultural Research Service
USDA
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

ABSTRACT

Aster lateriflorus (L.) Britt., a perennial broadleaves weed, began invading sugarcane fields about 1972, and, because the seed is carried by wind, has spread rapidly throughout the sugarcane and non-cropped areas of southern Louisiana. Investigations showed that the weed was becoming a problem in sugarcane fields, primarily because it is not controlled by 2,4-D. Several herbicides were evaluated as foliar treatments by spraying the spring growth of *Aster* in April or May. The average control in four experiments were: silvex, at 2 lb per acre, 55%; dicamba, at 2 lb per acre, 79%; asulam, at 4 lb per acre, 45%; picloram, at 1 lb per acre, 87%; and 2,4-D, at 2 lb per acre, 5%. The average control in two experiments were: silvex, at 1 lb per acre, 15%; dicamba, at 1 lb per acre, 55%; a mixture of asulam, at 3 lb per acre, and silvex, at 1 lb per acre, 63%; a mixture of asulam, at 3 lb per acre, and silvex, at 2 lb per acre, 77%; DOWCO-233 (3,5,6-trichloro-2-pyridyloxy-acetic acid), at 1 lb per acre, 46%; DOWCO-233, at 2 lb per acre, 76%; and a commercial formulated mixture of 2,4-D, at 2 lb per acre, mecoprop, at 1 lb per acre, and dicamba, at 0.2 lb per acre, 41%. Most herbicide treatments which gave about 50% or more control stunted *Aster* plants, so that they remained relatively small during the growing season and produced few flowers.

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[1] Only the Abstract of the paper was available for the Proceedings.

CONTROLLING *EQUISETUM PREALTUM* RAF. IN FIELD DRAINAGE DITCHES OF SOUTHERN LOUISIANA[1]

R. W. Millhollon
U. S. Sugarcane Field Laboratory
Agricultural Research Service
USDA
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

ABSTRACT

Equisetum is perennial weed that grows in damp soil and reproduces from both spores and rhizomes. In recent years, it has become a problem in drainage laterals in sugarcane and other crops in southern Louisiana, because the dense vegetative growth impedes the flow of water through these laterals. The USDA conducted field experiments to evaluate several herbicides for *Equisetum* control; the herbicides were divided into two groups, i.e. those that kill weeds at relatively low rates when applied to weed foliage, and those that sterilize the soil when used at high rates. The four herbicides asulam, at 4 lb per acre, glyphosate, at 6 lb per acre, amitrole, at 4 lb per acre, and picloram, at 1 lb per acre, when applied as low-rate foliage treatments, were not effective. The four herbicides bromacil, tebuthiuron, sodium chlorate and DPX 3674 (3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4 (1H, 3H)-dione), when applied as soil sterilants, were more effective. Bromacil and tebuthiuron, applied at 15 to 30 lb per acre, and DPX 3674, at 10 to 20 lb per acre, gave excellent control. Sodium chlorate, at 600 lb per acre, gave only about 50% control.

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[1] Only the Abstract of the paper was available for the Proceedings.

THE EFFECT OF LOW TEMPERATURE ON FLOWERING OF SUGARCANE IN LOUISIANA IN 1976[1]

Dr. Elias D. Paliatseas
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

The flowering of sugarcane was greatly affected by temperature in the low 40's (Fahrenheit) that prevailed in October, 1976. By controlled photoperiodic treatments, all stages of flowering in sugarcane could be made to occur in September and October. These stages included flower initiation, flower elongation, the last leaf stage and flower emergence. Only flower elongation and the last leaf stage were affected by low temperatures in October, 1976. The flowering stalks of 25 sugarcane varieties died at the elongation or the last-leaf stage, due to temperatures in the low 40's. The flowering stalks of 10 other sugarcane varieties were unaffected at the initiation or the vegetative stage by the low temperatures experienced in October, 1976. A determined number of stalks from each of these 10 varieties were moved into the greenhouse on December 15, 1976, and on January 15, 1977. Flowering was depressed in those cane stalks moved into the greenhouse on December 15, 1976. In contrast, flowering was promoted in those cane stalks that were moved into the greenhouse on January 15, 1977. The temperature and photoperiod were kept constant inside the greenhouse during December, 1976, and January, 1977. Therefore, the differences in flowering could be due to other factors, such as light intensity or quality.

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[1] Only the Abstract of the paper was available for the Proceedings.

SUGARCANE VARIETY TESTING IN TEXAS[1]

Sim A. Reeves
Texas Agricultural Experiment Station
Weslaco, Texas

ABSTRACT

A sugarcane industry was established in Texas, in 1972, based upon seven sugarcane varieties that had shown good yields and high sugar contents in early research test trials. Since most of the varieties imported into Texas have been either a commercial variety or a variety in the advanced testing stage in other sugarcane-growing areas, it is necessary that each variety receive a fair evaluation before being discarded. Because continuous and progressive evaluations of new sugarcane strains from breeding programs is essential to the growth and prosperity of the Texas industry, a new sugarcane variety-testing program was initiated in 1975. Up until that time, the number of new varieties each year was small and easy to handle. A six-stage program has been set up for variety evaluation: Stage I, imported varieties are planted in quarantine at College Station; Stage II, varieties are moved from College Station to the Rio Grande Valley of Texas; Stage III, varieties having sufficient seed cane are planted into a small replicated test; Stage IV, the varieties selected from the Stage III program are planted in four different areas of the Valley in different soil types; Stage V, the selected varieties from Stage IV are planted in a replicated test at four locations on different soil types; Stage VI, varieties selected for release to the growers are planted at one location and a mill run is made to determine milling qualities. The variety is then released to the growers for production.

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[1] Only the Abstract of the paper was available for the Proceedings.

MATURITY STUDIES OF SUGARCANE VARIETIES IN FLORIDA

Edwin R. Rice
USDA, ARS
Canal Point, Florida

ABSTRACT

The Florida sugarcane industry needs varieties high in sucrose throughout the harvest season, which usually extends from late October to early April. A 3-year study of maturation patterns of seven varieties, including the three most recently released varieties in Florida, revealed important differences in the amounts of sucrose on the various sampling dates. For example, CP 63-588, the most extensively grown variety in Florida, showed an increase from 190.7 to 263.4 lb of sugar per ton of cane from November 1 to March 1 in the first-stubble crop. CP 68-1026, a recently released, early-maturing variety, yielded 208.9 lb of sugar on November 1 and increased to 244.6 lb on March 1. All varieties averaged less sugar per ton of cane in the second-stubble crop than in the plant-cane and first-stubble crops because of the severe freezes in January 1977. CP 65-357 yielded more sugar per ton of cane on March 1 than the other varieties following the damaging temperatures in the second-stubble crop.

INTRODUCTION

Varieties play an important role in the successful production of sugarcane in Florida. Varieties are needed that mature at different times throughout the harvest season, which normally extends from late October to early April. A knowledge of the changes in juice quality of each variety during this period is extremely important to the grower and processor; this is particularly true after mature cane has been damaged by low temperatures as occurred in January 1977. A program of testing promising varieties for maturity date has been conducted for several years (3, 4, 6). The purpose of this paper is to report the latest results of that program.

TEST PROCEDURES

An experiment designed to measure the relative maturity qualities of seven varieties was conducted on Terra Ceia muck at Hatton Bros. farm during the 1974, 1975, and 1976 harvest seasons. Hatton Bros. farm is located 11 miles southeast of Lake Okeechobee. The commercial variety CP 63-588, and six promising experimental varieties, CP 65-357, CP 68-1020, CP 68-1022, CP 68-1026, CP 68-1067, and CP 68-1145 were planted in a randomized block design on November 9, 1973. The varieties CP 65-357, CP 68-1026, and CP 68-1067 were released for commercial production in Florida in 1975. The main plots of the experiment were three rows wide and 30 ft long, with three replications of each variety. Row width was the standard 5 ft. Each plot was subdivided into five 6-ft plots for the five dates of sampling. A different row was sampled in each of the three crops (plant cane, first, and second stubble); this eliminated bias associated with time of harvesting during the previous crop. The margins around the experimental plots were buffered to eliminate border effects and mechanical damage, but individual 3-row plots were not buffered. Two lines of seed cane were planted in each furrow. Fertilizing, cultivating, controlling of insects and rodents, burning, loading, and hauling were done according to established plantation practices for adjacent commercial fields. There were no drainage or irrigation problems. The mature cane was not damaged by freezing temperatures during the plant cane and first stubble crops, but the second stubble was severely damaged (2).

Fifteen representative stalks were cut by hand from each 1-row plot on or near the first day of November, December, January, February, and March in each of the three harvest seasons.

Crusher juice was analyzed for brix and apparent sucrose. Indicated yields of sugar per ton of cane were calculated with the Winter-Carp-Geerligs formula as simplified by Arceneaux (1).

Data were analyzed as a two factor factorial (varieties x sampling dates). The means were compared by Duncan's multiple range test.

RESULTS AND DISCUSSION

Average yields of sugar per ton of cane for plant cane and first stubble increased from about 200 lb on November 1 to about 245 lb on March 1 (Tables 1 and 2). Second-stubble sugar yields on November 1 and December 1 were about 25 lb higher than in the plant and first-stubble crops (Table 3); however, by January 1 sugar yields were about equal for all three crops. During the third week of January 1977 the second stubble was exposed to 18.2 hours of 28° or below (Table 4). This caused the reduction in sugar for the February 1 and March 1 sampling dates.

Variety CP 63-588 yielded 216, 218, 250, 239, and 250 lb of sugar per ton of cane, respectively, on the five plant-cane harvest dates and was surpassed only by CP 68-1026 in the average of the above yields (Table 1). First stubble CP 63-588 produced 253 and 263 lb of sugar per ton of cane on the

February and March sampling dates, respectively, thus surpassing all other varieties in the test for high sugar late in the season (Table 2). Variety CP 63-588 averaged 217 lb of sugar per ton of cane in the average of the second-stubble data and thus surpassed all other varieties in this category (Table 3). Variety CP 63-588, released to the Florida industry in 1967, presently ranks first in number of acres planted (7).

Table 1. Indicated yields of 96° sugar, in pounds per ton of cane, in plant cane (1974-75) of 7 varieties in Florida.

	Date of harvest					
Variety	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	Mean
CP 68-1026	231.1 A*	249.1 A	255.9 A	235.9 AB	235.5 A	241.5
CP 63-588	215.9 ABC	217.7 B	250.2 A	238.7 A	250.4 A	234.6
CP 68-1022	224.3 AB	216.9 B	253.5 A	226.8 ABC	243.7 A	233.0
CP 68-1067	207.8 BC	218.0 B	252.7 A	226.5 ABC	249.5 A	230.9
CP 68-1020	196.2 C	213.1 B	249.1 A	228.4 AB	248.2 A	227.0
CP 65-357	198.8 C	213.2 B	232.2 B	220.7 BC	237.1 A	220.4
CP 68-1145	164.7 D	179.7 C	216.4 C	215.9 C	232.7 A	201.9
Mean	205.5	215.4	244.3	227.6	242.4	

*Means within columns followed by the same letter do not differ significantly (5% level) according to Duncan's multiple range test.

Table 2. Indicated yields of 96° sugar, in pounds per ton of cane, in first stubble cane (1975-76) of 7 varieties in Florida.

	Date of harvest					
Variety	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	Mean
CP 68-1022	213.5	234.6	244.2	245.5	254.2	238.4 A*
CP 68-1026	220.6	236.1	240.7	237.8	242.9	235.6 AB
CP 65-357	208.9	226.2	246.4	229.3	244.6	231.1 ABC
CP 68-1020	191.4	215.7	238.9	240.0	243.9	226.0 BC
CP 68-1067	182.4	210.8	233.1	241.1	261.2	225.7 BC
CP 63-588	190.7	200.6	205.9	253.4	263.4	222.8 C
CP 68-1145	156.3	194.9	196.6	217.2	224.4	197.9 D
Mean	194.8 D	217.0 C	229.4 B	237.8 B	247.8 A	

*Means within rows or columns followed by the same letter do not differ significantly (5% level) according to Duncan's multiple range test.

Table 3. Indicated yields of 96° sugar, in pounds per ton of cane, in second stubble (1976-77) of 7 varieties in Florida.

	Date of harvest					
Variety	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	Mean
CP 63-588	233.9	236.6	248.7	214.6	151.3	217.0 A*
CP 65-357	231.8	238.3	252.4	200.2	160.2	216.6 A
CP 68-1022	235.4	254.1	234.4	198.9	153.3	215.2 A
CP 68-1026	235.7	244.9	246.8	211.3	122.2	212.2 AB
CP 68-1020	239.3	245.1	229.0	194.8	104.8	202.6 AB
CP 68-1067	219.9	240.0	247.9	198.8	68.6	195.0 B
CP 68-1145	172.9	204.9	208.0	167.4	34.3	157.5 C
Mean	224.1 A	237.7 A	238.2 A	198.0 B	113.5 C	

*Means within rows or columns followed by the same letter do not differ significantly (5% level) according to Duncan's multiple range test.

Table 4. Number of hours with temperatures at or below freezing (32°) at Hatton Bros. farm between January 18-26, 1977.

Date	Minimum	Temperatures 32°	31°	30°	29°	28°	27°	26°	25°	24°	23°	22°	21°
Jan. 18	26	7.9	6.9	6.4	3.4	3.1	2.2	0.7	--	--	--	--	--
19	32	0.3	--	--	--	--	--	--	--	--	--	--	--
20	21	14.0	13.7	13.3	13.0	12.3	11.5	11.0	9.4	8.8	5.2	2.0	0.8
21	28	7.7	7.0	6.0	4.9	2.0	--	--	--	--	--	--	--
22	27	8.8	8.1	6.1	2.2	0.8	0.3	--	--	--	--	--	--
26	28.5	3.6	2.9	1.8	0.7	--	--	--	--	--	--	--	--

An early-maturing variety, CP 68-1026, which was released in 1975, averaged 241 lb of sugar per ton of cane on the plant-cane harvest dates and was not surpassed by any other variety in this respect (Table 1). The variety significantly exceeded all other varieties in sugar per ton on December 1. First-stubble CP 68-1026 produced 221 and 236 lb of sugar per ton of cane, respectively, on the November and December harvest dates and surpassed all other varieties in the above categories (Table 2).

CP 65-357, a strong-stubbling, high-tonnage variety, produced more sugar per ton of cane on January 1 in both first and second stubble than any other variety (Tables 2 and 3). CP 65-357 exceeded all other varieties in sugar per ton of cane on March 1 in second stubbling following severe freeze damage in January. Gascho and Miller noted the superior keeping quality of CP 65-357 in another experiment.[1] The superior keeping quality of CP 65-357 was also observed in Louisiana during the past harvest season (5).

The early-maturing variety, CP 68-1022 produced early high sugar in all three crops and maintained desirable sugar levels throughout the season except following the freeze (Tables 1-3). Despite this favorable characteristic, CP 68-1022 was not released because of its low tonnage production.

On November 1 in second stubble, CP 68-1020 yielded more sugar (239 lb) than any other variety (Table 3); however, the variety has not been released to the industry because of mediocre yields of cane and sugar per acre.

On March 1, CP 68-1067, a new, low-fiber, large-barreled variety, produced high yields of sugar per ton of cane in both plant and first-stubble crops (Tables 1 and 2). The variety was surpassed only by CP 63-588 in the above categories. CP 68-1067 produced only 69 lb of sugar per ton of cane on March 1 in second stubble following the severe January freezes (Table 3), and this poor keeping characteristic could hinder the expansion of this variety by the industry.

CP 68-1145, a vigorous high-tonnage, low sucrose, unreleased variety, produced inferior yields of sugar per ton of cane on all dates in each of the 3 years (Tables 1, 2, and 3). This unacceptable performance has eliminated CP 68-1145 from consideration as a variety for commercial production.

ACKNOWLEDGEMENT

The author is grateful to Hatton Bros. farm for providing the necessary land, labor, and equipment for this experiment.

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EFFECT OF ROW WIDTH ON YIELDS OF THREE SUGARCANE VARIETIES IN FLORIDA

Edwin R. Rice
USDA, ARS
Canal Point, Florida

ABSTRACT

Sugarcane in Florida is commercially grown in 5-foot rows. Growers and scientists in other sugarcane growing areas have had limited success in increasing yields by decreasing the row width. A 3-year study of 3- and 5-foot row spacings of three commercial varieties in Florida, revealed little advantage in decreasing the row width to 3 feet. Cane yields from the 3-foot rows were 5% higher than from the 5-foot rows in the average of all crops although the yields were not significantly different. Average indicated yields of sugar per ton of cane were significantly higher in the 5-foot rows than in the 3-foot rows in both plant cane and second stubble. There was no significant difference between the indicated yields of sugar per acre from the two row widths.

INTRODUCTION

Sugarcane growers and scientists throughout the world are interested in determining the row-spacing that will give them optimum production and return for their efforts. In 1965, Hebert et al. (2) recorded higher yields of cane and sugar per acre from narrow rows in three plant cane experiments in Louisiana. Matherne (3) has recently shown significant increases in tonnage of plant cane but small increases in stubble crops by decreasing the row width in Louisiana. Since the question of row spacing is also important in Florida, an experiment was conducted to test the effect of row width on yields of cane and sugar per acre, yield of sugar per ton of cane, and average stalk weight.

TEST PROCEDURES

The experiment was conducted on Terra Ceia muck at Hatton Bros. farm, located 10 miles east of Pahokee, Florida, during the 1973, 1974, and 1975 harvest seasons. Three commercial varieties (CP 56-63, CP 63-306, and L 61-49) were planted in a split-plot design on September 22, 1972. These varieties were chosen because their shading characteristics represent the range available in commercial varieties in Florida. The main plots in this experiment were row widths, with varieties being sub-plots. Each subplot was four rows wide and 35 ft long, with four replications. The margins around the experiment were buffered to eliminate border effects and mechanical damage, but individual four-row plots were not buffered. Two lines of seedcane were planted in each furrow.

A standard 3-row furrowing plow was used to open the furrows for the 5-foot row-spacings and was adjusted to open the 3-foot row-spacings.

The 5-foot rows were fertilized with 0-0-50 at 200 pounds per acre, and the 3-foot rows received about 330 pounds of the same fertilizer per acre. Both spacings received equal amount of fertilizer on a row basis. The 5-foot row plots were cultivated according to standard plantation practices and the same equipment was used for the 3-foot row plots after necessary adjustments were made. The control of insects and rodents, burning, loading, and hauling were accomplished in the same manner as for adjacent commercial fields. The mature cane was not damaged by freezing temperatures during the 3-year period.

After burning, the cane in all plots was cut by hand and weighed. Fifteen full-length stalks were taken at random from each replication at each of the three harvests. The samples were then weighed and milled. Crusher juice was analyzed for brix and apparent sucrose. Indicated yields of sugar per ton of cane were calculated with the Winter-Carp-Geerligs formula as simplified by Arceneaux (1).

RESULTS AND DISCUSSION

Cane yields from 3-foot rows were 5% higher than from 5-foot rows in the average of all crops, although the yields were not significantly different (Table 1). CP 63-306 and L 61-49 yielded more cane per acre than CP 56-63 in the average of both row width in both plant and stubble crops.

Average indicated yields of sugar per ton of cane were significantly higher in the 5-foot rows than in the 3-foot rows in both plant cane and second stubble; however, the 3-foot rows yielded significantly more pounds of sugar per ton of cane than the 5-foot rows in the first-stubble harvest (Table 2). CP 63-306 yielded more sugar per ton of cane in the average of both row widths than both CP 56-63 and L 61-49 in plant cane and first stubble. There was no significant difference among varieties in indicated yield of sugar per ton of cane in second stubble.

Table 1. Yields of cane from rows spaced 3 and 5-feet apart on Terra Ceia muck, 1973-75.

	Average yield and harvest date									Average yield all crops	
	Plant cane			First-stubble[1]			Second-stubble				
	3/25/74			3/14/75			3/9/76				
Variety	Row width 3'	5'	Variety mean	Row width 3'	5'	Variety mean	Row width 3'	5'	Variety mean	Row width 3'	5'
	Tons cane/acre										
CP 56-63	33.21	25.68	29.44	28.48	32.81	30.64	33.12	33.91	33.52	31.60	30.80
CP 63-306	53.55	48.01	50.78	41.08	37.22	39.15	41.55	39.61	40.58	45.39	41.61
L 61-49	59.94	53.82	56.88	40.72	42.18	41.45	45.78	44.70	45.24	48.81	46.90
Row width mean[2]	48.90	42.50	45.70	36.76	37.40	37.08	40.15	39.41	39.78	41.93	39.77
LSD[3] between var. means .05			6.23			2.59			3.01		
.01			8.74			3.64			4.22		

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[1] A significant row width x variety interaction was evident in this test and was probably due to the severe rat damage that occurred only in CP 56-63.

[2] No significant difference in tons of cane per acre for different row width means within the same crop year.

[3] LSD = Least significant difference between any 2 values.

Table 2. Indicated yields of 96° sugar in pounds per ton of cane, from rows spaced 3 and 5-feet apart on Terra Ceia muck, 1973-75.

	Average yield and harvest date									Average yield all crops	
	Plant cane			First-stubble			Second-stubble				
	3/25/74			3/14/75			3/9/76				
Variety	Row width 3'	5'	Variety mean	Row width 3'	5'	Variety mean	Row width 3'	5'	Variety mean	Row width 3'	5'
CP 56-63	217.3	252.3	234.8	243.4	233.4	238.4	232.1	230.1	231.1	230.9	238.6
CP 63-306	235.0	270.7	252.8	259.7	250.0	254.8	228.1	233.3	230.7	240.9	251.3
L 61-49	213.1	239.3	226.2	249.0	235.7	242.4	220.7	226.6	223.6	227.6	233.9
Row width mean	221.8	254.1	237.9	250.7	239.7	245.2	227.0	230.0	228.5	233.1	241.3
LSD[1] between row width means .05	23.3			3.8			2.5				
.01	NS			7.1			NS				
LSD between var. means .05			10.5			4.8			NS		
.01			14.8			6.7			NS		

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[1] LSD = Least significant difference between any 2 values.

Indicated yields of sugar per acre were 1% higher in the 3-foot rows than in the 5-foot rows in the average of all crops (Table 3). CP 63-306 and L 61-49 produced significantly higher yields of sugar per acre in all crops than CP 56-63 when averaged over both row widths.

Table 3. Indicated yields of 96° sugar, in pounds per acre, from rows spaced 3 and 5-feet apart on Terra Ceia muck, 1973-75.

	Average yield and harvest date									Average yield all crops	
	Plant cane			First-stubble			Second-stubble				
	3/25/74			3/14/75			3/9/76				
Variety	Row width 3'	5'	Variety mean	Row width 3'	5'	Variety mean	Row width 3'	5'	Variety mean	Row width 3'	5'
CP 56-63	7,252	6,479	6,866	6,938	7,657	7,298	7,690	7,803	7,746	7,293	7,313
CP 63-306	12,538	12,996	12,767	10,668	9,305	9,986	9,468	9,241	9,354	10,891	10,514
L 61-49	12,775	12,879	12,827	10,140	9,941	10,040	10,117	10,129	10,123	11,011	10,983
Row width mean[1]	10,855	10,785	10,820	9,249	8,968	9,108	9,092	9,058	9,075	9,732	9,603
LSD[2] between var. means .05			1,401			669			826		
.01			1,964			938			1,158		

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[1] No significant difference in pounds of sugar for different row width means within the same crop year.

[2] LSD = Least significant difference between any 2 values.

There was no significant difference between the average stalk weights from the two widths in plant cane or first stubble; however, in second stubble the average stalk weight of the 5-foot rows was 11% higher than the average stalk weight in 3-foot rows (Table 4). The average stalk weight of CP 56-63 was significantly higher than those of CP 63-306 and L 61-49 in plant cane; however, there were no significant differences for stalk weight among varieties in the first and second-stubble crops.

Table 4. Average stalk weight of cane, in pounds, from rows spaced 3 and 5-feet apart on Terra Ceia muck, 1973-75.

	Average stalk weight and harvest date									Average stalk weight all crops	
	Plant cane 3/25/74			First-stubble 3/14/75			Second-stubble 3/9/76				
	Row width		Variety	Row width		Variety	Row width		Variety	Row width	
Variety	3'	5'	mean	3'	5'	mean	3'	5'	mean	3'	5'
CP 56-63	3.9	3.7	3.8	2.8	2.8	2.8	2.7	3.1	2.9	3.1	3.2
CP 63-306	3.3	3.3	3.3	2.7	2.7	2.7	2.8	2.8	2.8	2.9	2.9
L 61-49	2.9	3.2	3.0	2.4	3.0	2.7	2.7	3.0	2.8	2.7	3.1
Row width mean	3.4	3.4	3.4	2.6	2.8	2.7	2.7	3.0	2.8	2.9	3.1
LSD[1/] between row width means											
.05	NS			NS			0.2				
.01	NS			NS			NS				
LSD between var. means .05			0.4			NS			NS		
.01			0.5			NS			NS		

[1/] LSD = Least significant difference between any 2 values.

A review of the literature (2, 3) revealed that yields of cane and sugar per acre have been increased by decreasing the width of rows. This was especially true in the plant cane crop. It seems that more plants can be grown on an acre with narrower rows but the actual number of tillers that develop into mature stalks depends on the growing conditions. Closer spacing of rows to increase the number of plants results in competition for available light and space and results in more of the tillers being suppressed. Our data showed that the 3-foot rows yielded more cane than the 5-foot rows in the average of all three crops but the difference was greatest in the plant cane.

It is generally agreed that growth habit affects the variety response to row spacing, and that an erect variety produces better on narrow rows than a leaning or prostrate variety. Our data agreed with this assumption when CP 63-306 and L 61-49, which are more erect than CP 56-63, outyielded CP 56-63 in all crops of the narrower row treatment.

An important economic disadvantage of narrow spacings is the increased quantity of seedcane required. Approximately 67% more seedcane is needed to plant cane on 3-foot rows than on 5-foot rows. Another disadvantage of 3-foot rows would be the necessity to change all present equipment which is set up for 5-foot rows.

ACKNOWLEDGMENT

The author is grateful to Hatton Bros. farm for providing the necessary land, labor, and equipment for this experiment.

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SCREENING FOR FIBER CONTENT IN THE LOUISIANA STATE UNIVERSITY BREEDING PROGRAM[1]

C. A. Richard
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

Acceptable fiber content is one of the essential objectives of the Louisiana sugarcane breeding programs. New equipment at the St. Gabriel Branch of the Louisiana Agricultural Experiment Station has made the determination of fiber percentage relatively easy. The procedure is the press method of cane analysis, the same technique used in Hawaii and other areas. The equipment consists of a cutter-grinder apparatus, to prepare the cane samples, and a press, to extract the juice, leaving the residue for fiber analysis. Analyses of the variance in a three-replication test conducted in 1975 and 1976 showed significant differences in fiber percentage among nine commercial varieties known to be different in fiber content. The analysis of variance of these six-stalk samples between these commercial varieties and 26 experimental varieties also indicated that several of the unreleased varieties were unacceptably high in fiber content. The association between fiber percentage in different years for the 35 varieties was very strong, with a correlation coefficient of 0.76**. Associations between individual replications of any one year and the average fiber percent of two years were also strong, with correlation coefficients averaging 0.88**. The data indicated that selection for fiber content was relatively easy and accurate, and that screening for unacceptable fiber might be accomplished using only one replication at an early stage.

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[1] Only the Abstract of the paper was available for the Proceedings.

SEXUAL COMPETITIVENESS OF IRRADIATED MALE SUGARCANE BORER MOTHS AND THEIR F_1 MALE PROGENY[1]

J. W. Sanford
U. S. Sugarcane Field Laboratory
Agricultural Research Service
USDA
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

ABSTRACT

Percent egg hatch was used to evaluate sexual competitiveness of irradiated (10 Krad) adult male sugar cane borers, Diatraea saccharalis (F.), and their first-generation male progeny. Treated and untreated males were caged with untreated females in various ratios. The treated male parents were found to be comparable in competitiveness to untreated males. However, the progeny from treated males was not competitive with that from untreated males.

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[1] Only the Abstract of the paper was available for the Proceedings.

CROP LOGGING: A GUIDE FOR MAXIMIZING SUGARCANE YIELDS IN THE LOWER RIO GRANDE VALLEY[1]

A. W. Scott, Jr.
Rio Farms
Edcouch, Texas,
J. R. Thomas
Agricultural Research Service
Weslaco, Texas
and
B. Sleeth
Rio Farms
Edcouch, Texas

(Contribution from Soil and Water Conservation Research,
Southern Region, Agricultural Research Service, USDA,
Weslaco, Texas, and Rio Farms, Edcouch, Texas)

ABSTRACT

Sugarcane processed at the W. R. Cowley Sugar House, Santa Rosa, Texas, during the 1974-75 season was generally low in sugar. The suspected causes were excessive use of nitrogen fertilizer and late season irrigations. Foliar analysis is currently being used in other sugarcane-growing areas to monitor changes in the mineral composition and moisture status of sugarcane crops. The purpose of this study was to evaluate the use of foliar diagnosis of sugarcane to identify factors that may be associated with low sugar production in the Lower Rio Grande Valley of Texas. Approximately 900 acres of sugarcane under cultivation by 15 farm demonstrators were included in the survey. Varieties were CP 52-68, CP 61-37, CP 44-101, L 62-96 and NCo 310, and included both plant and ratoon cane. Fields were sampled at intervals from late May through October. Leaves and sheaths numbered three to six were collected before 10:00 a.m. for nitrogen (N), phosphorous (P) and moisture determinations. Growth of five primary stalks was also measured weekly. Cane and sugar yield data were supplied by the mill. The leaf sheath moisture content decreased from 82 to 75% from July 1 through October. The moisture content of plant cane was slightly higher than ratoon cane in the two varieties NCo 310 and CP 52-68. The growth index (green weight of the sheath samples) decreased with age and was significantly correlated with the moisture content of the sheath ($r = 0.67^{*}$, percent N ($r = 0.73$)* and percent P ($r = 0.65^{*}$) content of the leaves. There was a consistent downward trend of leaf N with age. Fluctuation in the N-age curves were related to the moisture status of the plant. Leaf N and sheath moisture concentrations were significantly related ($r = 0.96^{**}$). The relationship among N concentration (percent N) of the leaves, plant age (A, climatological week) and leaf sheath moisture (M) content of sugarcane variety CP 52-68 was described by the multiple regression equation:

$$\text{percent N} = 35.11 - 0.68_{2} + 0.006\,M^{2}$$
$$-0.15A + 0.003A^{2}$$

The highly significant coefficient of determination indicated that plant age and sheath moisture accounted for 59 percent (R^{2} x 100) of the variability in leaf N concentration. Differences in the amount of N fertilizer applied to the eight fields, the soil's capacity to supply N and the level of management could also affect the change in the N concentrations of the plant with age. The leaf P concentration decreased with the increasing age of the plant. However, the P concentration was strongly affected by the N ($r = 0.82^{**}$) and moisture ($r = 0.83^{**}$) status of the plant, stage of plant growth and availability of soil P ($r = 0.87^{*}$). The ratio of sugar to cane yields was inversely related to the leaf N concentration ($r = 0.82^{**}$) and sheath moisture ($r = 0.52^{*}$) at harvest. The slopes of the regression curves suggested that a 0.5% decrease in the leaf N concentration increased the ratio by 2.25 percent, while a 5.0% decrease in sheath moisture increased the ratio by 1.1%.

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[1] Only the Abstract of the paper was available for the Proceedings.

FLOODING FOR THE CONTROL OF THE WHITE GRUB, *BOTHYNUS SUBTROPICUS*, IN FLORIDA[1]

T. E. Summers
Agricultural Research Service, USDA
Canal Point, Florida

ABSTRACT

Bothynus subtropicus Blatch., first found causing serious damage to sugarcane in 1972, is presently the most destructive of seven species of grubs identified as attacking sugarcane in Florida. The larvae of *B. subtropicus* destroy the roots, latent buds or shoots and regenerative portion of the underground stems, thus destroying the potential for the subsequent ratoon to produce a satisfactory stand of cane. Presently, the most effective control of the grub is flooding the standing cane for five to seven days during the months of August to November, or flooding the cut stubble after harvest, prior to February. Flooding standing cane for 120 to 168 hours did not reduce sucrose and gave satisfactory control of *B. subtropicus*. There is evidence that some species are more difficult to control. A method is needed for detecting the presence of the larvae prior to the time that the damage it inflicts becomes obvious.

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[1] Only the Abstract of the paper was available for the Proceedings.

GROWTH AND YIELD OF SUGARCANE AS AFFECTED BY ROW SPACING AND IRRIGATION REGIME

J. R. Thomas, F. G. Salinas[1], and L. N. Namken
USDA, ARS
Weslaco, Texas

ABSTRACT

The influence of row spacings and irrigation regimes on depth and rate of soil water depletion, growth, yield, and quality of plant and ratoon sugarcane was investigated. Treatments consisted of all combinations of three irrigation regimes and three row spacings arranged in a randomized block design with three replications. Sugarcane (variety NCo 310) was irrigated when 40, 60, and 80% of the available soil water in the top 60 cm of soil had been depleted. Row spacing treatments were 122, 152, and 182 cm. Frequent irrigations (40% irrigation regime) restricted root development to the upper 60 cm of the soil profile; whereas, under the 60 and 80% irrigation regimes, plants extracted significant amounts of water to 120 cm depth. Rate of stalk elongation was significantly affected by the irrigation regimes. Regression coefficients indicated that seasonal mean daily growth rates of stalk elongation decreased 0.42, 0.24, and 0.17 cm/day for each 10% decrease in available soil water under the 40, 60, and 80% irrigation regimes, respectively. Plant cane irrigated under the 40% regime outyielded the less frequently irrigated cane (80% regime) by 15.8 metric tons/ha. Reducing row spacing from 182 to 122 cm increased cane yields by 7.9 and 11.1 metric tons/ha in the plant and first ratoon crops, respectively, but had no effect on following crops. Narrow row spacing significantly increased percentages of pol, brix, and purity in the juice.

INTRODUCTION

Development of water management practices that will produce high sugarcane yields and efficiently use a limited supply of irrigation water requires a knowledge of the relationships among plant growth, sugarcane yield, and availability of soil water. Most of this information was not available for sugarcane growers in the Lower Rio Grande Valley (LRGV) of Texas when commercial sugarcane plantings were initiated in 1972. Because of differences in cultivars, length of growing season, soils, and climate, information from other sugarcane growing areas may not be directly applicable.

Thomas and Oerther (1975) observed that mean daily rates of stalk elongation during the boom stage of growth were affected more by available soil water than by nitrogen (N) fertilization rates and suggested that frequent irrigations during this period might maintain higher growth rates for longer periods and increase cane and sugar yields. Robinson (1963) reported that sugarcane stalk elongation was not restricted until the soil water tension at a 30 cm depth exceeded 2 bars.

Ameen et al. (1971) found that reducing the time between successive irrigations from 20 to 10 days increased yields of millable cane and sugar. Singh and Singh (1971) reported that irrigation at 75% depletion of available soil water produced higher cane and sugar yields than did irrigation regimes based on 25, 50, and 100% depletion of available water in the top 30 cm of soil.

Most data show that cane yields increase as row spacings decrease, if water is not limiting (Thompson and du Toit, 1965). Hebert et al. (1965) concluded that row spacings of less than 1.5 m were not profitable with cane cultivars being grown in Louisiana. However, recent Louisiana studies by Matherne (1972a) showed that decreasing the row spacing from 1.8 to 0.9 m increased cane yields by 25%. Matherne (1972b) also noted a cultivar-row spacing interaction. Cultivar CP 48-103 (low vigor-high sucrose) responded better to narrow rows than did CP 61-37 (high vigor-average sucrose). Cane yields increased 27.3 and 19.1%, respectively. Since similar sugarcane cultivars make considerably more growth in the LRGV than in Louisiana, corresponding yield responses to narrow rows may not be obtainable.

This study was designed to examine the effects of irrigation regime and row spacing on growth, rooting depth, and yields of sugarcane.

MATERIALS AND METHODS

This 4-year study (1972-1975) was initiated in December 1971 by planting sugarcane cultivar NCo 310 on Hidalgo (Typic Calciustolls) sandy clay loam. Phosphorus fertilizer (45 kg/ha of P_2O_5) was placed in the planting furrow before seeding. Plant (1972) and third ratoon (1975) cane crops were fertilized with 224 kg/ha of N, while the first and second ratoon crops were fertilized with 170 kg/ha of N (as NH_4NO_3). Foliar analysis suggested a need for P in 1974; therefore, 100 kg/ha of P_2O_5 was applied to the third ratoon crop.

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[1] Now USDA, ARS, New Orleans, Louisiana.

Treatments consisted of all combinations of three irrigation regimes and three row spacings arranged in a randomized complete block design with three replications. The sugarcane was irrigated when 40, 60, and 80% of the available water in the top 60 cm of soil had been used. However, sufficient water was metered onto each plot to replenish the entire 1.5 m soil profile. Interrow spacings were 122, 152, and 182 cm. Plots were six rows wide by 15.2 m long.

Soil water was measured using the neutron scattering method. Access tubes for the neutron proble were placed in each plot, and measurements were made at 30-cm intervals to a 1.5-m depth immediately before and within 24 hours after irrigation. In addition, the amount of available water in the soil profile at any given time was calculated using evapotranspiration, precipitation, and irrigation data (Jensen et al., 1971) and sugarcane crop coefficients developed for the LRGV (Salinas and Namken, 1976).

Stalk growth was determined weekly by measuring the distance from a permanent mark at the base of the stalk to the last visible dewlap at the top of the stalk of five primary stalks randomly selected within each plot.

Leaves and sheaths number three through six were collected from five plants in each plot several times during the season. The middle third of the leaf blade was analyzed for total N by the Gunning method (Lepper, 1945) and for total P by the Bolin and Stamberg (1944) and Barton (1948) methods. The sheaths were ovendried at 70 C for 24 hours for moisture determination.

Plant population counts were made at harvest. Cane was hand cut in December or January from 12 m of the center two rows. Juice of 20 stalks from each plot was analyzed for apparent sucrose, purity and total dissolved solids (Meade, 1963).

RESULTS AND DISCUSSION

Table 1 gives the number and amounts of irrigations and annual and rapid-growth stage precipitation amounts in each crop-cycle. The number of irrigations and the amount of water applied in each year varied considerably among the irrigation regimes. Row spacings significantly affected the amounts of water applied and the frequencies of irrigation of plant cane under the 40% irrigation regime. The 80% irrigation regime as compared to the 40% reduced the number of irrigations by five and conserved about 109 cm of water during the 4 year test.

Table 1. Number (No.) and amount (Amt) of irrigations for various row spacings and irrigation treatments and annual and rapid-growth stage precipitation in each crop cycle.

Irrigation regime	Row spacing	Plant		1st rtn		2nd rtn		3rd rtn		Mean	
		No.	Amt	No.	Amt	No.	Amt	No.	Amt	No.	Amt
%	cm		cm		cm		cm		cm		cm
40	122	8	69.9	6	53.0	12	97.5	6	47.2	8	66.9
	152	6	44.2	5	40.8	12	94.6	6	45.9	7	56.4
	182	5	36.0	4	35.8	12	94.6	5	37.6	7	51.0
Mean			50.0		43.2		95.6		43.6		
60	122	5	48.0	3	35.8	8	86.4	4	40.0	5	52.6
	152	4	37.5	3	35.3	8	84.7	4	41.4	5	49.7
	182	5	43.5	3	35.4	8	83.4	4	40.4	5	51.4
Mean			44.0		35.5		84.8		40.6		
80	122	1	13.9	0	0.0	5	74.9	3	44.5	2	33.3
	152	1	15.0	0	0.0	5	74.1	2	29.2	2	29.6
	182	1	14.7	0	0.0	5	73.9	2	29.3	2	29.5
Mean			14.5		0.0		73.3		34.3		
Annual precipitation			84.4		109.4		56.7		70.7		
Mid -May through July precipitation			48.7		19.3		6.6		31.8		

Soil Water Depletion

Fig. 1 shows soil-water depletion by depth as a function of time and irrigation regimes in 1974. Changes in soil-water with each 30-cm depth increment are indicated as well as the dates of irrigation and rainfall. The data points are averaged soil water measurements for three replications of the 152-cm row spacing. Soil-water depletion profiles were similar for all three row spacing treatments. The first ratoon crop, 1973, was harvested in January 1974 and regrowth of the second ratoon crop was first noted on February 16.

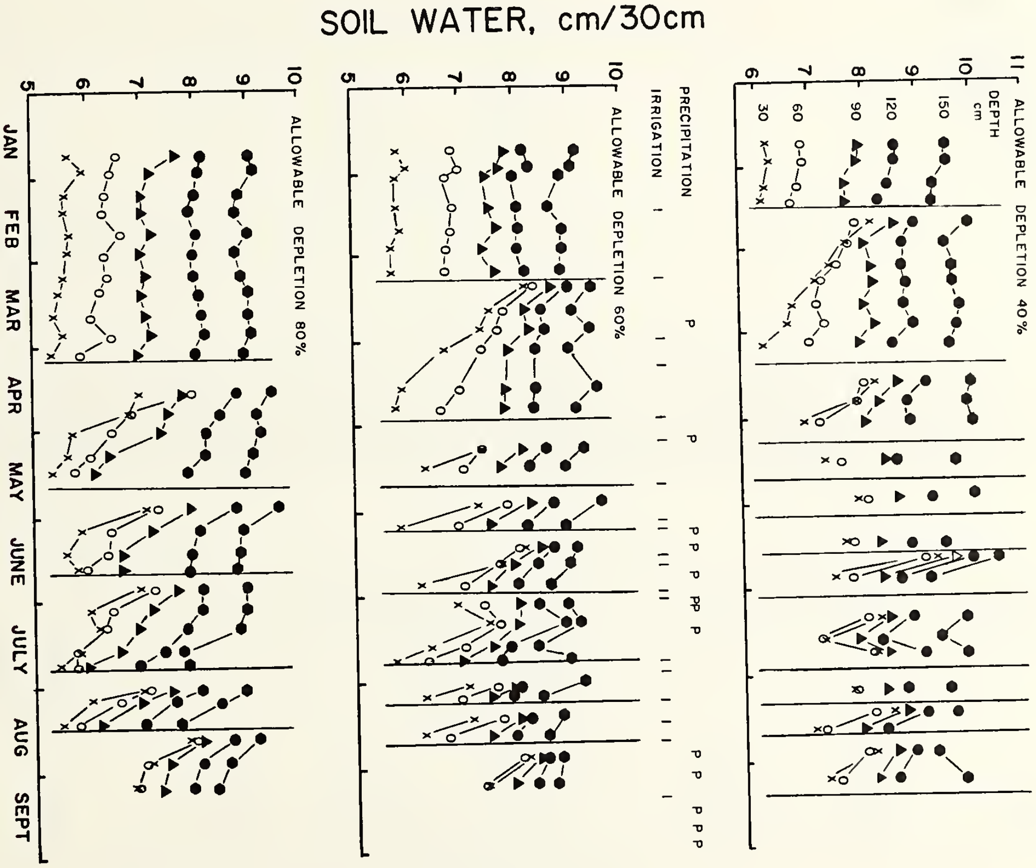

Figure 1. Changes in soil water content with depth as a function of time and irrigation regimes in 1974.

Soil-water depletion profiles were similar under all irrigation regimes before the initiation of rapid stalk elongation in May, when soil water decreased mainly in the upper 60 cm of the soil profile. The relatively large supply of available water associated with the 40% irrigation regime evidently prevented a deep rooting system from being established. Water was depleted primarily from the upper 60 cm of the soil profile throughout the season under this treatment. Whereas, when 60 and 80% of the available water in the upper 60 cm of profile was depleted before irrigation, the sugarcane removed water from the 90 and 120 cm depths, respectively.

Growth Rates

Fig. 2 shows the relationship between the mean sugarcane stalk elongation rates and soil water availability. The slopes of the regression lines represent the average daily growth rate for May 16 to August 4, 1975. They indicated that a 10% decrease in available water reduced the seasonal mean daily growth rates by 0.42, 0.24, and 0.17 cm/day, under the 40, 60, and 80% irrigation regimes, respectively. Growth rates were low (circled values) under high levels of available water (>90%) when rainly periods followed an irrigation and they may be due to poor aeration in the root zone. The high growth rates (circled values) at relatively low levels of available water were associated with brief rain showers and the apparent stalk elongation probably reflects cell enlargement. The circled values were not used in the regression analysis. Mean soil water tensions were approximately 1, 2, and 4 bars in the upper 60 cm of profile after each irrigation cycle under the 40, 60, and 80% irrigation regimes.

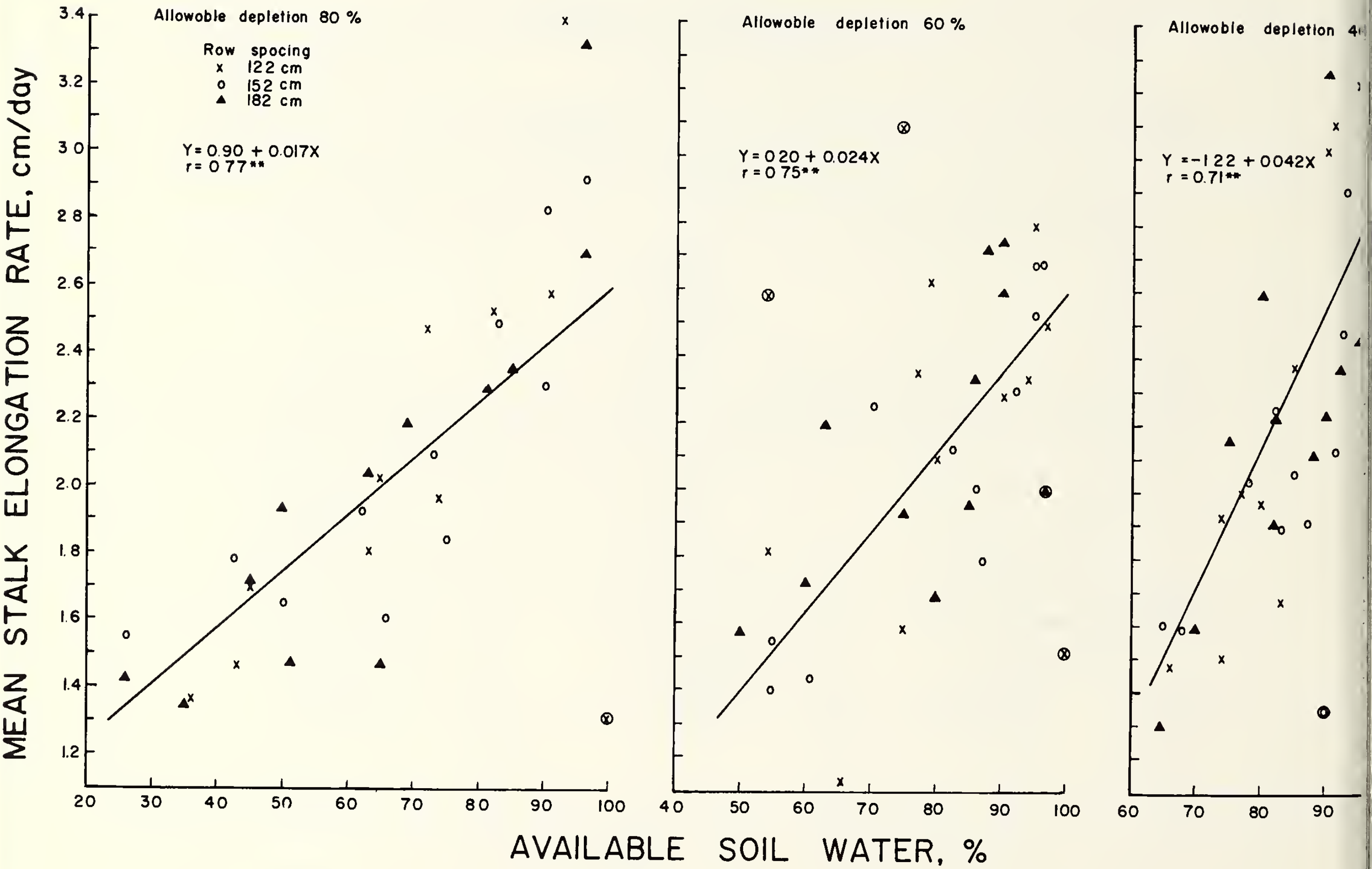

Figure 2. Sugarcane stalk elongation rates as affected by soil water availability.

Yields

Irrigation regimes and row spacings significantly affected cane yields (Table 2). Cane grown under the 40 and 60% irrigation regimes generally outyielded that grown under the 80% irrigation regime. Cane yield response was largest for plant cane. The 40% irrigation regime increased yields by 15.8 metric tons/ha. Decreasing row spacings from 182 to 122 cm increased cane yields by 7.9 and 11.1 metric tons/ha in the plant and first ratoon crops, respectively. However, narrowing the row spacings did not significantly increase yields of the second and third ratoon crops. Yields at the 152-cm row spacing did not differ significantly from those obtained with either of the other two row spacings.

Table 2. Mean cane and sugar yields as affected by irrigation regime and row spacing.

Crop cycle	Irrigation regime[1] - %			Row spacing - cm		
	40	60	80	122	152	182
			Cane Yields			
			metric tons/ha			
Plant	147.8a[2]	147.7a	132.0b	144.6a	145.7a	136.7b
1st rtn	132.7a	141.0a	135.4a	142.0a	136.3ab	130.9b
2nd rtn	117.4a	119.2a	114.2a	117.9ab	112.6a	124.0b
3rd rtn	117.8a	120.7a	114.3a	120.1a	114.4a	118.9a
Mean	128.9	132.2	125.2	131.2	127.3	127.6
			Sugar Yields			
			metric tons/ha			
Plant	15.1a[2]	13.9b	11.7c	15.1a	13.2b	12.4b
1st rtn	12.8a	14.1a	12.9a	14.3a	13.4b	12.2c
2nd rtn	11.9a	13.1b	11.5a	12.0a	11.9a	12.7a
3rd rtn	13.4a	14.0a	13.5a	14.0a	13.5a	13.4a
Mean	13.4	13.8	12.4	13.9	13.0	13.7

[1] Allowable depletion of available water in top 60 cm of soil profile.

[2] Row values followed by same letter are not significantly different at 5% probability level by Duncan's multiple range test.

The irrigation regimes and row spacings affected three yield components--mean stalk length, stalk weight, and number of millable stalks (Table 3). Cane stalks from the 40% irrigation regime were longer than those from the 80% irrigation regime and in some crops heavier. Row spacings did not significantly affect stalk length. However, stalks growing on 182-cm spaced rows were significantly heavier, but fewer than those on 122-cm spaced rows each year of the study. Frequent irrigations (40% irrigation regime) increased the millable stalk population of the plant cane, but decreased the stalk population of the second ratoon crop.

Table 3. Mean stalk length and weights and number of millable stalks as affected by irrigation regimes and row spacing.

Crop cycle	Irrigation regime[1] - %			Row spacings - cm		
	40	60	80	122	152	182
			Stalk Length			
			cm			
Plant	284a[2]	280a	260b	272a	282a	274a
1st rtn	259a	268a	248a	261a	260a	253a
2nd rtn	250a	239b	232b	235a	242a	244a
3rd rtn	237a	236a	221b	237a	231a	227a
			Stalk Weight			
			kg/stalk			
Plant	1.36a[2]	1.35a	1.25b	1.21a	1.34b	1.40b
1st rtn	1.23a	1.27a	1.25a	1.19a	1.29b	1.27b
2nd rtn	1.02a	0.96ab	0.89b	0.94a	0.93a	1.00b
3rd rtn	1.24a	1.22a	1.24a	1.19a	1.20a	1.32b
			No. of Millable Stalks			
			stalk/ha			
Plant	110372a[2]	110224a	104738b	119149a	108576b	97651c
1st rtn	108094a	111259b	109221ab	119675a	105947b	102954b
2nd rtn	115381a	124281ab	129584b	125428b	121032a	122736a
3rd rtn	95153	98682	92188	100611b	95378ab	90046a

[1] Allowable depletion of available water in top 60 cm of soil profile.

[2] Row values followed by same letter are not significantly different at 5% probability level by Duncan's multiple range test.

Correlation coefficients (Table 4) indicated that cane yields were statistically related to the millable stalk population of the plant, first and third ratoon crops, and to the mean stalk weights of the second ratoon crop. Stalk weights were inversely related to the number of millable stalks. Within the range of plant densities established in this study, multiple regression analysis indicated that the millable stalk population and mean stalk weights were equally important in accounting for yield variability in all crop cycles (Table 5).

Table 4. Correlation coefficients (r) relating cane yields with the number of millable stalks or the mean stalk weights in different crop cycles.

Crop cycle	Millable stalk population	Stalk weight
Plant	0.65*	0.20
1st rtn	0.79*	0.13
2nd rtn	0.07	0.67*
3rd rtn	0.66*	0.25

*Significant at 5% probability level.

Table 5. Multiple regression equations relating cane yields (Y) to number of millable stalks (X_1) and mean stalk weights (X_2) in different crop cycles.

Crop cycle	Regression $Y = a + bX_1 + cX_2$	R	Standard partial regression coefficient $b^1Y_{1 \cdot 2}$	$b^1Y_{2 \cdot 1}$
Plant	$Y = -110.9 + 0.0012X_1 + 95.78X_2$	0.99**	1.22	0.94
1st rtn	$Y = -198.6 + 0.0029X_1 + 165.24X_2$	0.96**	1.39	1.38
2nd rtn	$Y = -108.1 + 0.0009X_1 + 117.92X_2$	0.99**	1.02	1.37
3rd rtn	$Y = -109.5 + 0.0012X_1 + 90.91X_2$	0.99**	1.14	0.90

**Significant at 1% probability level.

Sugar yield responses to the irrigation regimes were significant (p=0.05) for only the plant cane. However, sugar yield differences in the first ratoon cane were significant at the 10% probability level. Decreasing the row spacing significantly increased sugar yield of the plant and first ratoon crops (Table 2). The increases in sugar yields with frequent irrigations (40% irrigation regime) were due mainly to a higher plant population; whereas, the increased sugar yields from narrower row spacings also reflected a corresponding significant increase in the apparent sucrose (pol), brix, and purity of the juice (Table 6).

Apparent sucrose (pol) content of juice from the second ratoon crop correlated significantly with sheath moisture content ($r_{y1} = -0.453$*) and leaf P concentration ($r_{y2} = -0.634$**) at harvest. However, the P concentration was significantly affected by the moisture status of the plant (r = 0.810**). The partial correlation ($r_{y\,1.2} = 0.135$) between pol and sheath moisture content at a single P level was not significant. This suggested that the correlation between percent pol and sheath moisture reflected the strong moisture-P relationship.

Yields of plant and first ratoon cane increased as row spacing decreased, but not as much as that reported in the Louisiana studies (Matherne, 1972). Decreasing row spacing from 182 to 122 cm required more seed cane (2.4 metric tons/ha), but increased total yields by 19.0 metric tons/ha in two cropping cycles.

An irrigation-management practice based on 60% depletion of the available water from the top 60 cm of soil seems to be the most efficient in terms of maintaining high growth rates and yields while conserving limited irrigation water supplies.

Table 6. Apparent sucrose (pol), brix, and purity of sugarcane juice as affected by irrigation regimes and row spacing.

Crop cycle	Irrigation regime[1] - %			Row spacing - cm		
	40	60	80	122	152	182
			% Pol			
Plant	13.7	13.2	12.9	14.0b[2]	12.9a	13.1a
1st rtn	13.6	13.9	13.2	14.1b	13.6ab	13.0a
2nd rtn	13.9a	15.1b	14.0a	14.3ab	14.9b	13.7a
3rd rtn	15.3	15.6	15.8	15.6	15.7	15.3
			% Brix			
Plant	16.9	16.4	16.2	17.1a	16.1b	16.3b
1st rtn	16.4	16.6	16.0	16.8b	16.3b	15.9a
2nd rtn	16.3a	17.5b	16.5a	16.7ab	17.3b	16.2a
3rd rtn	17.0	18.1	18.2	18.0	18.3	17.8
			% Purity			
Plant	18.1	80.5	79.7	81.9b[2]	79.8a	79.9a
1st rtn	82.9	83.5	82.5	83.6b	83.6b	81.6a
2nd rtn	85.3	86.1	84.9	85.4	86.4	84.5
3rd rtn	85.5	85.9	86.5	86.5	86.0	85.4

[1] Allowable depletion of available water in top 60 cm of soil profile.

[2] Values in same row followed by same letter are not significantly different at 10% probability level by Duncan's multiple range test.

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HISTORY OF SANTA ELISA NEW MILL TANDEM

Guillermo Aleman
Glade Sugar House
Belle Glade, Florida

La Usina Santa Elisa (Santa Elisa Sugar Factory) in the city of Sertaozinho, State of Sao Paulo, Brazil, has just completed the installation of a new cane grinding mill tandem in what we consider record time for the assembly of any equipment of this magnitude and characteristics.

The tandem is a Zanini-Farrel formed by two sets of cane-knives and six mills 42" x 84", each unit driven by a 1250 HP steam turbine for a nominal capacity of 8500 metric tons of cane in 24 hours.

All of the components of the tandem were fabricated by "Zanini Equipamentos Pesados" of the city of Sertaozinho, S.P., Brazil, under license from Farrel Company of Ansonia, Connecticut, U.S.A.

By the way, all the rest of the equipment in this sugar factory, (Usina Santa Elisa), steam generators, boiling house, centrifugals, etc., etc., the complete sugar factory, is from the Zanini Machinery and Foundry Shops, that is, 100% home made in Brazil.

And it is because of these two facts, a) the record time in which the tandem was assembled, and b) the domestic Brazilian manufacturing of all the equipment components, that we were enticed to present this paper that could very well have been titled: "What is going on in Brazil."

Physical Chronogram and Sequence of Assembling Charts.

As can be seen in the physical chronogram (Fig. 1) and sequence of assembly (Fig. 2), the schedule of erection of the building and the mill tandem was as follows:

(1) Demarcation of site (measurements) took place September 30, 1976.
(2) Piling was accomplished from September 25 to December 10, 1976.
(3) Excavations for blocks and foundation beams from October 1 to November 3, 1976.
(4) Blocks and foundation beam concrete casting from October 29 to November 6, 1976.
(5) Pillars and beams concrete casting from November 3 to December 30, 1976.
(6) Metal frame works from November 11, 1976 to January 30, 1977.
(7) Roof tiling from February 10 to February 20, 1977.
(8) Excavation of mill bases from December 10 to December 20, 1976.
(9) Mill bases concrete casting from December 20, 1976 to February 28, 1977.
(10) Internal floor from February 5 to February 28, 1977.
(11) Masonry from December 20, 1976 to February 20, 1977.
(12) Metal squares from November 25, 1976 to January 10, 1977.
(13) Placement of glasses from January 10 to January 20, 1977.
(14) Transportation of equipment from February 12 to May 10, 1977.
(15) Placement of bases, mill housings, general alignment and levelling, fixation and soldering from April 22 to May 5, 1977.
(16) Assembling of reductor gear trains and steam turbines from May 5 to June 1, 1977.
(17) General finishing of pipings, hydraulic and electric connections and experimental operations from June 1 to July 30, 1977.
(18) Cane grinding starting August 1, 1977.

Summing up, from demarcation of the site on September 30, 1976 to the date they started grinding operations on August 1, 1977 only 10 months had elapsed.

And out of the sequence of the assembling chart (Fig. 2) we can see that the critical path of the assembly comprised (point A) April 15 to (point Z) July 5, that is, 90 days.

The history of the Santa Elisa new mill tandem in particular and that of this Usina (sugar factory) itself and its directors is just an example of what is going on at present in Brazil and in the Brazilian sugar industry in particular.

Usina Santa Elisa has been producing sugar and alcohol since early in this century.

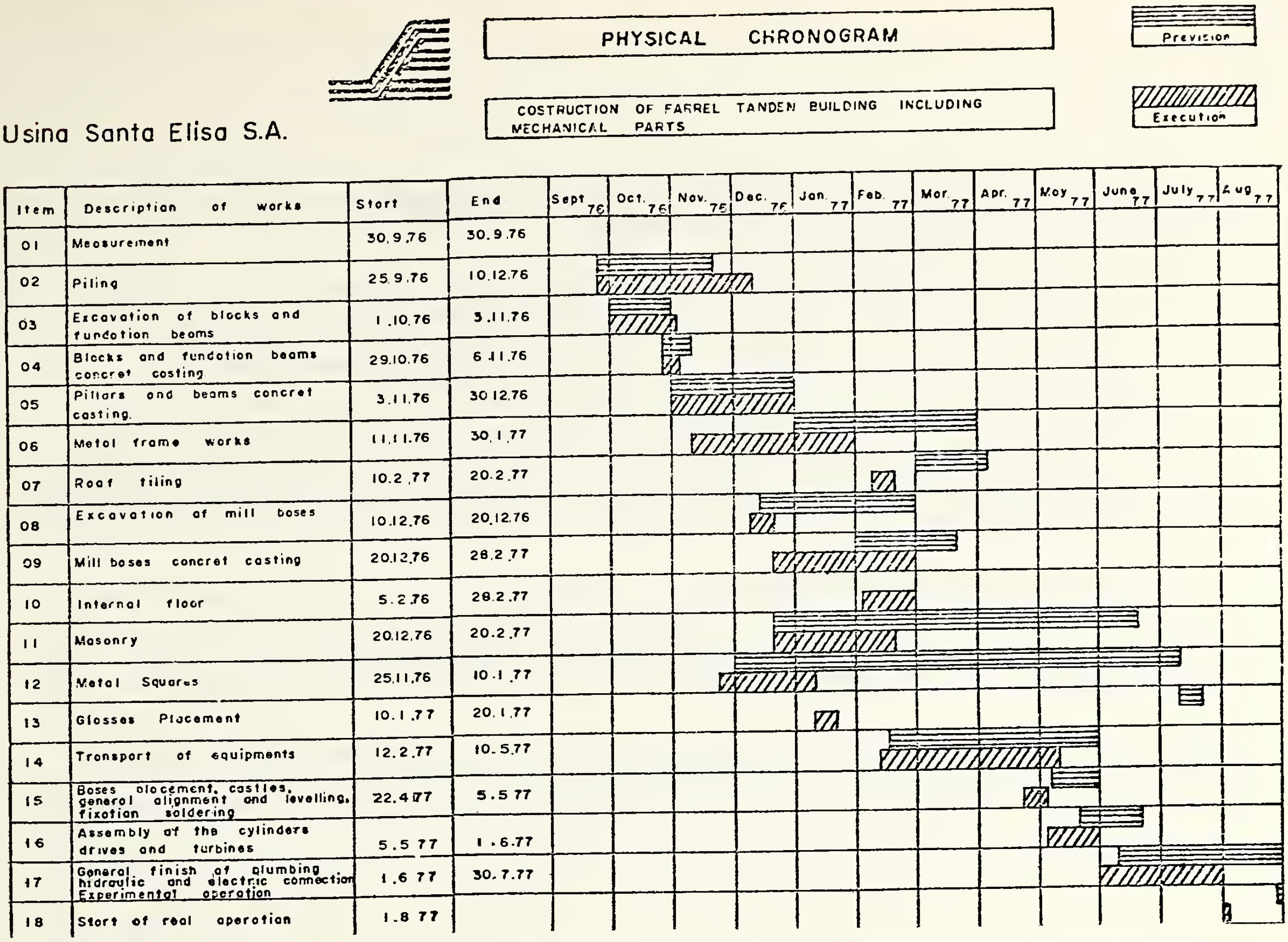
Until 1936, the then small sugar factory became an important sugar mill, and started a sequence of growing and improving that has never stopped. From a production of 300,000 bags of sugar of 60 kg each in 1956, it went up to 1,305,000 bags in 1974-75 and is presently equipped for a production estimated in 2,000,000 bags (120,000 tons) of sugar for 1977-78 crop.

Besides the sugar factory, it has an annexed alcohol distillery with a capacity of more than 300,000 liters of absolute alcohol per day, estimating the production for the present year in 50,000,000 liters of alcohol.

Usina Santa Elisa S.A.

PHYSICAL CHRONOGRAM

COSTRUCTION OF FARREL TANDEN BUILDING INCLUDING MECHANICAL PARTS



Item	Description of works	Start	End
01	Measurement	30.9.76	30.9.76
02	Piling	25.9.76	10.12.76
03	Excavation of blocks and fundotion beams	1.10.76	3.11.76
04	Blocks and fundotion beams concret costing	29.10.76	6.11.76
05	Pillars and beams concret casting.	3.11.76	30.12.76
06	Metal frame works	11.11.76	30.1.77
07	Roof tiling	10.2.77	20.2.77
08	Excavation of mill boses	10.12.76	20.12.76
09	Mill boses concret casting	20.12.76	28.2.77
10	Internal floor	5.2.76	28.2.77
11	Masonry	20.12.76	20.2.77
12	Metal Squares	25.11.76	10.1.77
13	Glosses Placement	10.1.77	20.1.77
14	Transport of equipments	12.2.77	10.5.77
15	Boses placement, castles, general alignment and levelling, fixation soldering	22.4.77	5.5.77
16	Assembly of the cylinders drives and turbines	5.5.77	1.6.77
17	General finish of plumbing hidraulic and electric connection Experimental operation	1.6.77	30.7.77
18	Start of real operation	1.8.77	

Fig. 1.

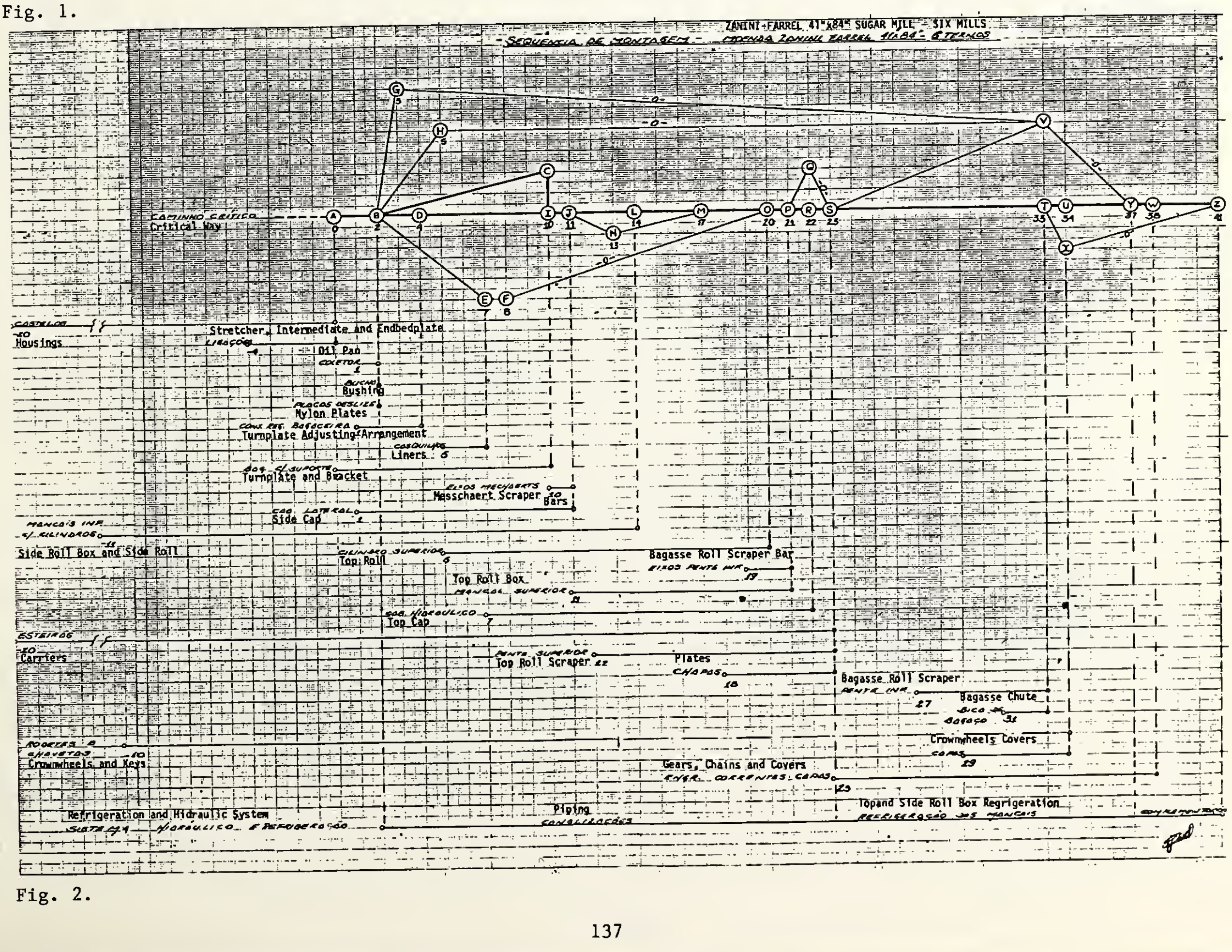


Fig. 2.

In 1972-73 the old factory, which already had a grinding capacity of 2500 metric tons per day was replaced by a complete new one with a nominal grinding capacity of 4500 m.t. per day with a new Type MB Zanini tandem of 2 sets of cane knives and 6 mills 37" x 80".

With this tandem and improvements made in the boiling house and steam generators, etc., the factory was able to grind 6870 m.t. of cane per day, as an average, hitting during several days the figure of 7000 m.t. Now, with the addition of the new Zanini-Farrel tandem, subject of this presentation, the grinding capacity of the plant has been brought up to 15000 m.t. for making sugar and alcohol.

The Usina has been owned and operated since 1936 by the firm M. Biagi & Co., of which Don Maurilio Biagi is Director President, Maurilio Biagi Filho, Director Gerente and Waldemar Manfrim Gerente Industrial.

The case of Usina Santa Elisa and its directors is presently repeated throughout the Brazilian sugar industry and is the response of this industry to the programs launched by the nation for the incrementation of alcohol production in large scale to substitute gasoline, not only alleviating the energy crisis, but at the same time creating jobs.

We would not like to close this presentation without quoting two phrases we heard in Brazil during the ISSCT XVI Congress recently held in that country.

One is from the Chairman of the Congress, Dr. Helio Morganti, who in his opening speed described the Brazilian alcohol program as aiming to "replace a nonrenewable mineral resource by renewable vegetal derivatives."

The other one, as a matter of fact, from Don Maurilio Biagi, President of Santa Elisa and of Zanini Equipamentos Pesados, when he told me: "We have enough land and sunlight and also plenty of hands available and willing to do the job of transforming solar energy into usable fuel through agro-industry means."

SUGGESTIONS FOR REDUCING TOTAL ORGANIC CARBON FOR IMPROVED BOILER OPERATION

Pedro R. Arellano and James S. Rauh
Olin Water Services
Kansas City, Kansas

ABSTRACT

Determinations of total organic carbon in condensates, boiler feed and boiler waters were made at several Florida sugar mills during several crops. Various laboratory tests were carried out to reduce the total organic carbon to improve boiler operation by reducing the organic contamination and, thus, their foaming and carry-over tendencies. As a result of these tests, the authors suggest in-plant trials increasing the vents for non-condensable gases in evaporators, vacuum pans and deaerators.

With the emphasis today on conservation, water ranks high among those natural resources that may be recycled. In the operation of modern sugar mills, maximum recovery and reuse of water is particularly evident. A primary example of water reuse is the recovery of evaporator condensates that are reused as boiler feedwater. Since the boiler plant is the heart of sugar mill operations, recycled water used for boiler feedwater must be of sufficient quality to maximize boiler availability and continued efficient generation of steam.

Evaporator condensates have been found to be contaminated with ammonia, carbon dioxide and organics such as fatty acids and acetaldehyde. It is generally known that organic contaminants can cause foaming, priming and carryover in boilers when they are present in high concentrations. Under these conditions, the boiler plant is subject to deposition in superheater tubes and turbines that may cause severe damage leading to tube failures, reduced power output and subsequent forced shutdown for cleaning or repairs. The presence of these volatile non-sugar contaminants can severely limit the efficient operation of the boilers, and it becomes imperative that their concentrations in the boiler water be minimized. Experience has shown that sugar mill boilers must be operated substantially below the published American Boiler Manufacturers Association guidelines for Total Solids in order to prevent foaming and carryover caused by these organics. This restriction of allowable Total Solids limits the number of concentrations at which the boiler may be operated. Lower operating concentrations are less efficient, since increased blowdown mean loss of Btu's, requires more chemical treatment, and results in higher operating costs.

The significance of operational difficulties that may result from increased organic contamination suggests that using total dissolved solids and total solids to establish operating parameters for the boilers is not sufficient to avoid such problems and achieve maximum operating efficiency. Total dissolved solids (ionizable) are normally measured by conductance, and total solids may be determined gravimetrically. Both of these methods are relatively simple. However, the organic contaminants discussed above are not ionizable and may be volatile, thus they are not detectable by the above means. There are, however, several methods available for determining concentrations of organics. We have chosen the measurement of total organic carbon for this purpose because of its ability to give a direct measurement of the organic contamination and its simplicity of operation as compared to the indirect oxidation-titration procedures. A brief outline of the total organic carbon procedure appears in Appendix I.

With the above purpose in mind, determinations of total organic carbon in condensates, boiler feedwaters and boiler waters were made on samples from numerous Florida Sugar Mills over several crops. Also, laboratory tests were conducted on these samples to attempt a reduction of their total organic carbon (organic impurities) content. The data are shown in Fig. 1 through 6 and the major observations are summarized below.

Fig. 1 and 2 demonstrate that significant levels of organic contamination are present in all of the mills sampled, as measured by total organic carbon. It may also be noted that conditions vary among the different mills. Fig. 2 also shows significant increases in organic contamination in 1976/77 over the previous crop that may be associated with freeze damage to the latter crop.

Fig. 3 and 4 compare data collected at two Florida mills. Columns 4 and 5 of the bar graphs of the various samples compare total solids and total organic carbon. Total solids were determined by evaporating a portion of sample to dryness at 110 C (230 F) and weighing the residue. If the total organic carbon did not contain volatile components, the total solids would be expected to be equal to or greater than the total organic carbon. The difference indicates that the greater part of the organic contamination in the condensate No. 1 and the boiler feedwater is volatile.

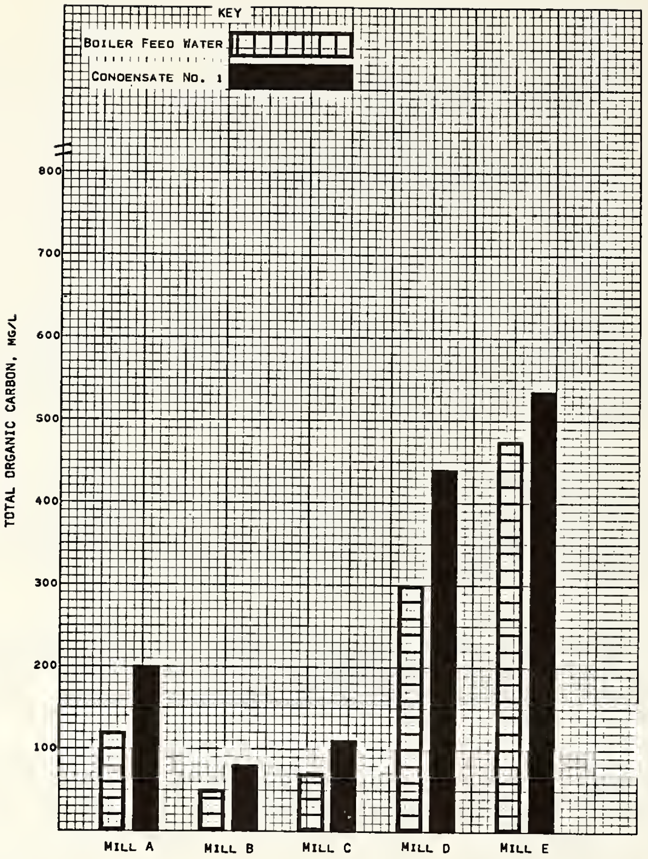


FIGURE 1 - TOTAL ORGANIC CARBON
IN BOILER FEED WATER AND CONDENSATE NO. 1 (1975/76 CROP) FOR
FIVE FLORIDA MILLS

Fig. 1. Total organic carbon in boiler feed water and condensate No. 1 (1975/76 crop) for five Florida mills.

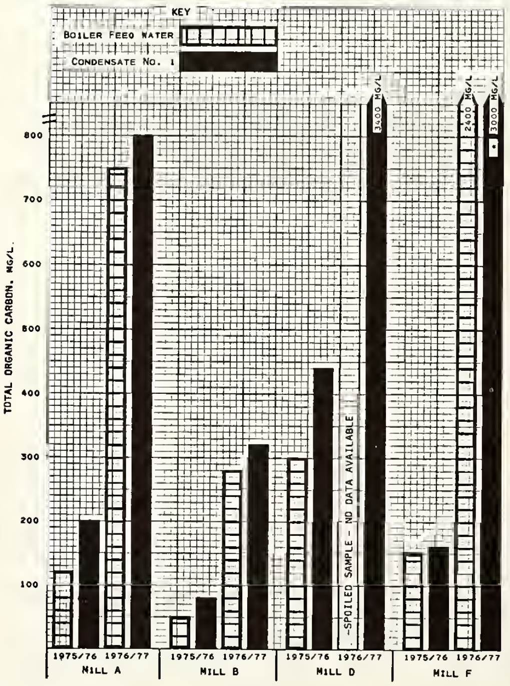


Fig. 2. Total organic carbon in boiler feed water and condensate No. 1 (1975/76 and 1976/77 crops) for four Florida mills. Note: Average of condensates Nos. 1 and 2 (5200 mg/1 and 1800 mg/1).

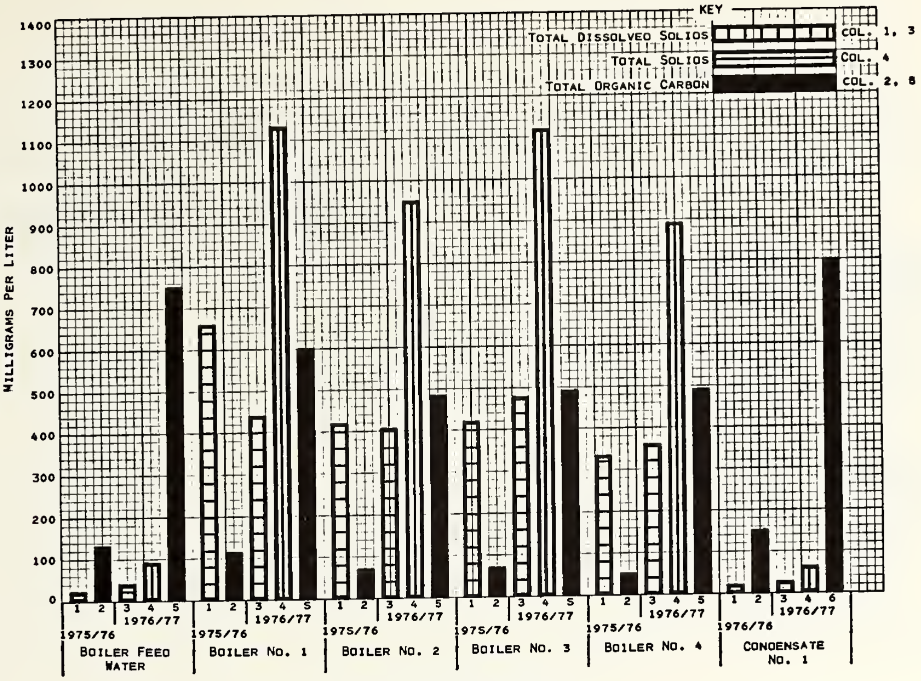


FIGURE 3 - COMPARISON OF TOTAL ORGANIC CARBON, TOTAL SOLIDS, AND TOTAL DISSOLVED SOLIDS IN BOILER FEED WATER, CONDENSATE NO. 1, AND BOILER WATER (1975/76 AND 1976/77 CROPS) FOR FLORIDA MILL "A"

Fig. 3. Comparison of total organic carbon, total solids, and total dissolved solids in boiler feed water, condensate No. 1, and boiler water (1975/76 and 1976/77 crops) for Florida mill "A".

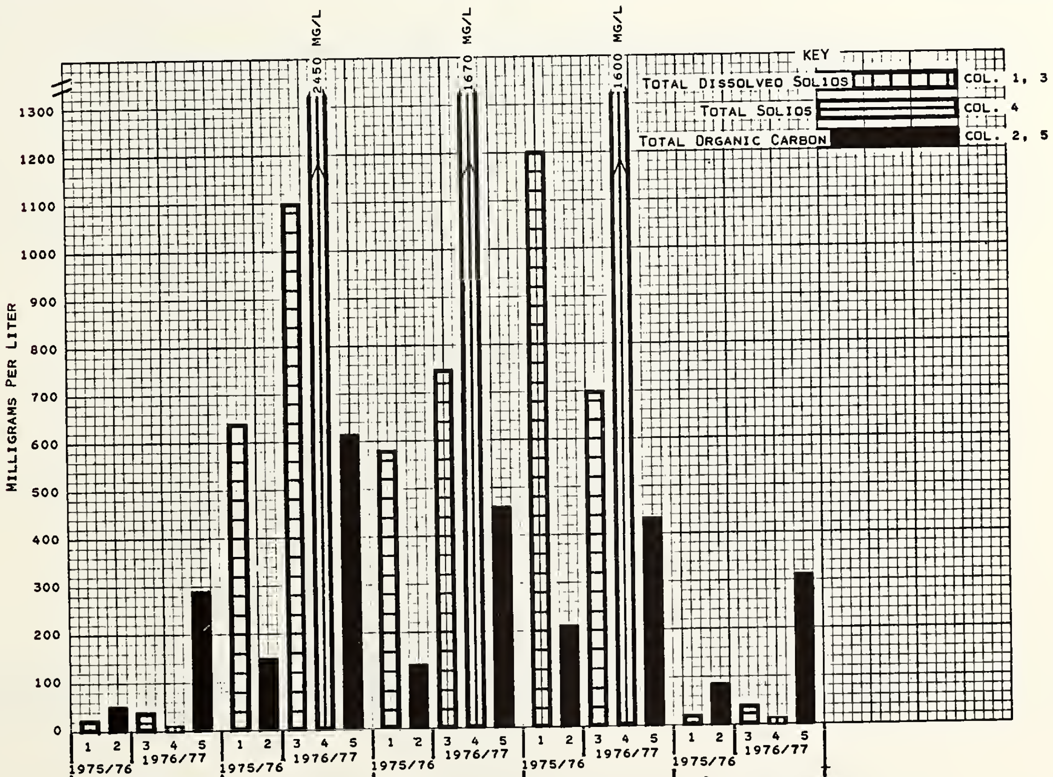
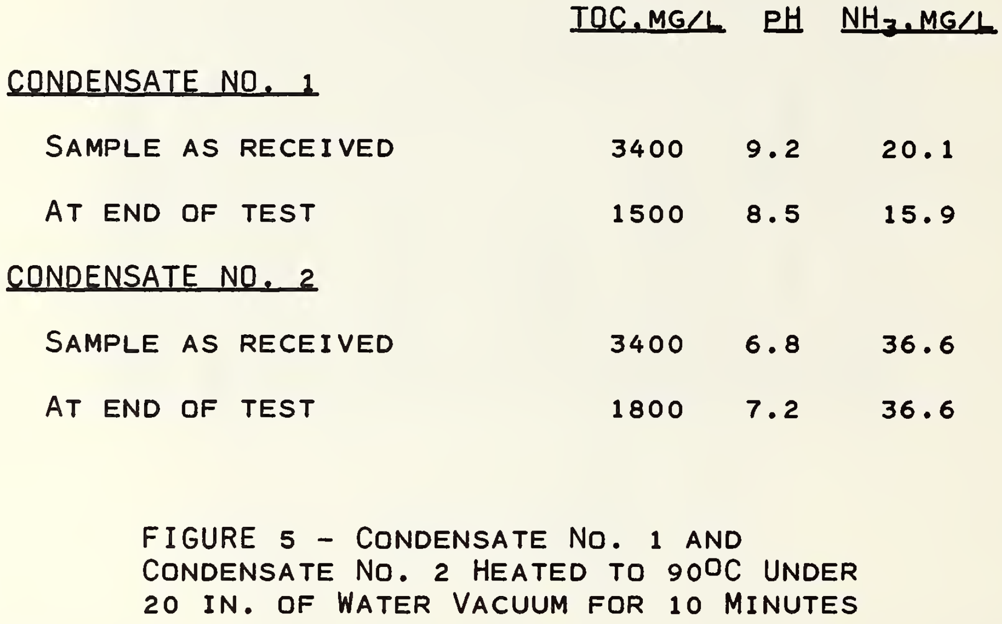


Fig. 4. Comparison of total organic carbon, total solids, and total dissolved solids in boiler feed water, condensate No. 1, and boiler water (1975/76 and 1976/77 crops) for Florida mill "B".



	TOC, MG/L	PH	NH_3, MG/L
CONDENSATE NO. 1			
SAMPLE AS RECEIVED	3400	9.2	20.1
AT END OF TEST	1500	8.5	15.9
CONDENSATE NO. 2			
SAMPLE AS RECEIVED	3400	6.8	36.6
AT END OF TEST	1800	7.2	36.6

FIGURE 5 - CONDENSATE NO. 1 AND CONDENSATE NO. 2 HEATED TO 90°C UNDER 20 IN. OF WATER VACUUM FOR 10 MINUTES

Fig. 5. Condensate No. 1 and condensate No. 2 heated to 90 C under 20 in. of water vacuum for 10 minutes.

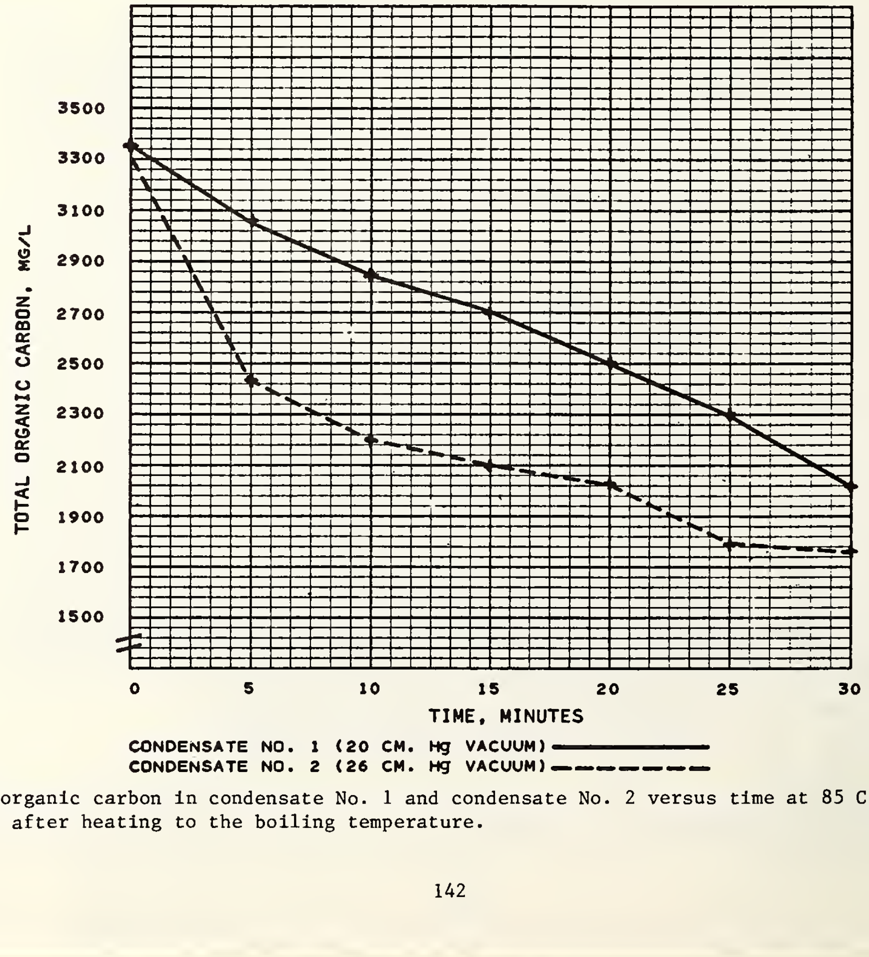


Fig. 6. Total organic carbon in condensate No. 1 and condensate No. 2 versus time at 85 C under vacuum after heating to the boiling temperature.

It can be seen in the boiler water samples that total organic carbon levels are only a fraction of the total solids. At the alkalinities experienced in the boilers, as much as 90% of certain volatile organics may be converted to non-volatile organic compounds which cause color formation. Also, comparison of the boiler water samples again shows the significant increase in organic contamination in the 1976/77 crop as compared to the previous crop.

A series of tests were carried out on some of the samples which were compared in the previous data. The tests are outlined below.

Condensate No. 1 in Fig. 3 had a total organic carbon content of 800 mg/l. After evaporating the sample to dryness at 110 C (230 F) the total solids amounted to only 60 mg/l. Condensate No. 1 in Fig. 4 had a total organic carbon content of 310 mg/l and total solids of less than 5 mg/l after evaporating sample to dryness in the same manner. Over 92% of the volatile organic components were driven off in these tests.

Condensate No. 1 and condensate No. 2 from a mill were held under 20" of water vacuum at 90 C (194 F) for 10 minutes with the results shown in Fig. 5. Total organic carbon was determined by the method outlined in Appendix I. Ammonia was determined by the Nesslerization method. Total organic carbon levels of both condensate No. 1 and No. 2 were substantially reduced. The pH of No. 1 was reduced from 9.2 to 8.5, apparently due to loss of ammonia. The pH of No. 2 increased from 6.8 to 7.2 possibly due to loss of acidic organic compounds leaving the ammonia content unchanged.

Condensate No. 1 and condensate No. 2 samples were held at 85 C (185 F) under 20 and 26 cm of mercury vacuum respectively for 30 minutes. Determinations of total organic carbon levels were made at five minute intervals. The results are plotted in Fig. 6. It is readily apparent in both cases that over 40% of the total organic carbon was removed by this method.

In the normal operation of evaporators and vacuum pans, noncondensable gases are continuously and systematically removed. The purpose is to prevent pressure buildup, and reduction of heat transfer and evaporator capacity. In addition, with lower vapor pressure above the condensate in the calandria, the condensate will have lower levels of volatile organic contaminants. Ammonia and carbon dioxide levels in the condensate will be lower, thus reducing evaporator tube corrosion and the amount of copper deposited in the boilers, and, helping to maintain the correct pH for minimizing corrosion without the use of neutralizing chemicals.

The above tests indicate that additional noncondensable gases (volatile organic contaminants) can be removed by improvements in venting or flashing of evaporators, vacuum pans and deaerators. The improved operational benefits achieved must be weighed against possible increases in operational costs to determine the most appropriate method for accomplishing this.

Finally, the test results also suggest that in-plant testing, to determine minimum obtainable levels of organic contamination in condensates, boiler feedwater and boiler water will improve boiler operation by reducing foaming, priming and carryover tendencies. The resulting boiler operation at higher concentrations will be more efficient. Further studies may be warranted to determine alternate methods of removing or reducing organic contamination in recycled water in sugar mills.

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APPENDIX I
Beckman Model 915 Total Organic Carbon Analyzer

Sample Preparation

If samples contain appreciable amounts of solids, these must be reduced in size and suspended prior to analysis so that they will pass through the syringe needle. Size reduction can be accomplished with a household blender by blending at high speed for 15 to 30 seconds.

Procedure

1. Turn Sample Select Valve to desired position (Total Carbon or Inorganic Carbon).
2. Fill syringe (20 ul):

  - a. Immerse needle in given sample or standard, withdraw plunger beyond stop, then return plunger to stop to expel air bubbles.
  - b. With tip immersed, expel all of syringe by depressing button.
  - c. Repeat a and b until syringe contains no air bubbles.

3. Wipe excess solution from syringe with a soft tissue, making sure no lint adheres to the syringe needle.
4. Remove plug from appropriate syringe needle guide, insert syringe and inject sample into the combustion tube.
5. Leave syringe in holder until peak has reached its maximum displacement, then remove syringe and replace plug.
6. Before injecting next sample into either channel, wait for the recorder to return to the normal baseline (zero).
7. Displacement of sample peaks on the recorder paper is converted to mg/l (ppm) carbon using the predetermined calibration curves.
8. After use, instrument settings and adjustments remain unchanged except placing the Infrared Analyzer in the Standby position, reducing the carrier gas flow rate to 10 cc/min, and turning HIGH temperature furnace to the LOW position.
9. Turn off recorder.
10. Remove and cover pen.
11. Rinse syringe with deionized water.

REPORT ON OPERATING THE W. R. COWLEY SUGAR HOUSE[1]

Dick Avrill and Segundo Valle
Rio Grande Valley Sugar Growers, Inc.
Santa Rosa, Texas

ABSTRACT

The first of two brief reports covers the use of a CF & I fiberizer at the Cowley Sugar House, including the use of tungsten carbide wear pads on the fiberizer. Other subjects include juice recycling for last mill maceration, to maximize factory sugar production, and mill roll welding to assist mill feeding. The second report discusses the use of magnesium oxide to prevent scaling in evaporators, with an explanation of the organic-type scale deposited on juice heaters and pre-evaporators when milling the variety CP 52-68. There is also brief mention of vapor bleeding from the two pre-evaporators, operated in parallel at Cowley, to increase the evaporator capacity, as well as give other benefits in the boiling house operations.

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[1] Only the Abstract of the paper was available for the Proceedings.

LIQUID CHROMATOGRAPHY AND THE SUGARS[1]

Scott R. Bushman

ABSTRACT

A brief description of chromatography and its applications is given, as well as a summary of preliminary experiments leading to the development of methods for sugar mixtures in a variety of materials. More work is required before liquid chromatography procedures can be recommended; however, this preliminary work shows that high-performance liquid chromatography is very quick and very sensitive for the determination of monosaccharides, sucrose and the more complex polysaccharides present in different products in a raw sugar factory.

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[1] Only the Abstract of the paper was available for the Proceedings.

MUNICIPAL SOLID WASTE AS SUPPLEMENTARY FUEL IN THE SUGARCANE INDUSTRY[1]

Cheng-Shen Fang and James D. Garber
Department of Chemical Engineering
University of Southwestern Louisiana
Lafayette, Louisiana

ABSTRACT

For years, natural gas and bagasse have provided the steam needed to process the sugarcane in Louisiana. Some sugar mills are reportedly 85% self-sufficient in energy supply by burning bagasse. However, recently, the high cost of natural gas, the Environmental Protection Agency's air pollution control regulations and the Federal Planning Commission's ruling on energy priority have cast a gloomy shadow on the future energy supply for the sugarcane industry. A potential solution to this problem is to extract energy from the shredded municipal solid waste, which is readily available in large quantities. Since the market value of municipal solid waste is negative, the cost of installing air-pollution control equipment can be offset, at least in part, by receiving the solid waste. The heating value of the as-received municipal solid waste is 4,600 BTU per pound, which is approximately equal to the heating value of bagasse. Engineering problems and their solutions, such as the required steps in preparing the municipal solid waste for combustion in existing furnaces and air-pollution control, are discussed. Furthermore, the economic analysis of the process is also presented.

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[1] Only the Abstract of the paper was available for the Proceedings.

ELECTRONIC CANE JUICE SAMPLERS AT GLADES SUGAR HOUSE

Luis Gandia
Planning Department
Sugar Cane Growers Cooperative of Florida
Belle Glade, Florida

ABSTRACT

Immediate cane load identification on cane carriers and continous visual tracking as each load travels from the dumping station to the first mill of each of two tandems as well as identification and visual travel of the corresponding juice samples on their way to the laboratory have been accomplished at the Glades Sugar House Mill in Florida. The in-house developed electronic samplers use readily available industrial type logic modules and CMOS MSI devices. The design is very flexible and adapts itself to different cane carrier configurations and physical size through the use of programmable digital counters and shift register modules. A plexiglass mimic panel using red light emitting diodes, LED, at the laboratory shows cane load positions as they travel to the first mill, juice samples in transit, and indication and record of the number of cane loads dumped and samples received at all times.

DESCRIPTION

Cane is hauled from the various fields to the mill in 44-foot-long cage trailers, each load being identified by a numbered cane weight ticket issued at the field and brought to the mill by the trailer driver. Some of the cane trailers are dumped into the cane storage pit; but the majority go to the direct dump station for immediate and continuous grinding.

The purpose of the juice sampler system is to properly identify each cane trailer load received at the dumper station, identify the juice sample received at the laboratory and have a continuous visual picture of the various cane loads as they travel in the two cane carriers towards the first mill.

An accounting of the number of cane loads dumped, loads in transit, samples received and in transit is incorporated in a graphic display (mimic) panel installed at the laboratory.

Fig. 1 is a schematic diagram of the West Mill juice sampler mimic panel. In this figure, C1W represents the first cane carrier which discharges on the second and last carrier C3W. C2W-A and C2W-B form a carrier used for feeding cane from the storage pit during those instances when direct dumping is stopped. Small circles in the panel represent LED's which are electronically turned on and off by the logic system to show the position of each cane load center line as they travel in the two carriers and whether one or two samples of juice are in transit towards the laboratory.

Fig. 1. West Mill juice sampler.

LED's 25 and 13 indicate the rate of travel of carriers C1W and C3W respectively. LED 26 indicates when a cane trailer is ready for dumping its cane load into carrier C1W and LED 27 is turned on when the dumper operator stamps the cane weight ticket delivered to him by the trailer driver. LED 2 is on as long as there is juice flow in the 2" stainless steel pipe going through the lab.

At the time a sample is received at the lab, LED 1 turns on and turns off after the required amount of juice has been collected. An electric ticket counter and sample counter are part of the display panel and are used to record the number of cane loads processed during the day.

DESIGN AND OPERATION

The design is based on the use of Digital Equipment Corporation K series industrial type logic modules and in house built MOS flip-flop cards and opto-coupler pulse generators.

A pulse generator is installed at the south end of cane carrier C1W intermediate speed reducer shaft and produces 10 pulses per shaft revolution. Each revolution of this shaft corresponds to a carrier travel of 0.0686 feet and it takes 1400 revolutions of the shaft for the dumped cane load center to travel the 96-foot distance between the dumping position and the end of the carrier, thus creating 14,000 pulses during this travel.

The pulse generator installed at cane carrier C3W main shaft produces 108 pulses for the 88 feet of its travel.

Carrier C1W is represented in the logic design by a 40 bit shift register and carrier C3W by a 36 bit shift register.

The 40 bit shift register for C1W requires 40 shift pulses for complete transferring of digital data from beginning to end, and since the pulse generator produces 14,000 pulses during its complete travel, a divide-by-350 digital module is incorporated in the design to produce the required 40 shift pulses. Similarly, the 36 bit long shift register for C3W requires 36 shift pulses for complete transferring of its input data and since C3W pulser produces 108 pulses for complete travel, a divide-by-3 digital module is incorporated.

The presence or absence of a cane load in the first carrier C1W is detected by a heavily built switch installed 12 feet back of the dumping position center line and 4 feet above carrier slats. This switch is operated by the cane as it travels towards the second carrier C3W and makes and breaks contact many times; so in order to hold this signal when the switch makes and breaks the first time, a type D flip-flop is used.

When the cane load has been dumped into carrier C1W and the flip-flop set to a logic 1, the dumper operator inserts the cane weight ticket into a ticket stamper and the ticket is stamped a sequential number. At the lab, there is another stamper that is connected in parallel with the dumper station stamper and hence operates asynchronously and stamps on a paper tape the same sequential number as that stamped on the cane weight ticket at the dumper station. The laboratory girl picks up this stamped paper tape and clips it on an empty stainless steel sample collector jar. Then she positions the jar to receive the sample at the correct time as determined by the systems logic.

This mimic panel gives the sampling operators a view of the various operations in the cane handling area, mill, and laboratory which are directly related to the direct dumped cane juice sampling process. It also indicates when direct dumping has been stopped and cane is being brought out from the cane storage area.

When a cane trailer reaches the dumping station and the trailer lifting jacks starts up, LED 26 lights up and will remain on until the load has been dumped, the hydraulic jacks are back to normal position, and the trailer leaves the station.

The dumper operator stamps the corresponding cane weight ticket and LED's 1 and 27 turn on simultaneously indicating that the cane trailer load was received at cane carrier C1W and its corresponding ticket properly stamped. The Ticket Counter will step up its reading by one count.

As cane carrier C1W moves toward C3W, LED 25 turns on and off indicating the rate of travel of this conveyor. When C1W is stopped, LED 25 stops flashing. After the cane has traveled 14.4 feet, LED 27 will go off, indicating that the system is now reset ready for the next cane trailer to be dumped as soon as there is adequate space in the cane carrier. LED 1 is still on; but it will go off and LED 2 will turn on when the cane travels 4.8 feet further. From this point on, for every 9.6 feet of travel, the next LED turns on and the one immediately behind it turns off. When the next cane load is dumped and its ticket stamped, LED's 1 and 27 will turn on. Now two LED's on C1W are on, each indicating the relative position of the dumped cane trailer loads center lines.

As long as cane carrier C1W keeps running, the two LED lights will move towards cane carrier C3W and when the cane has traveled the 96-foot length of carrier C1W, its LED light will disappear and LED 1 (first light on carrier C3W) will turn on, indicating that the cane load center line has now reached this carrier. Motion of carrier C3W is indicated by flashing LED 13 light.

As carrier C3W moves the cane towards the first mill, LED 2 turns on and LED 1 turns off and for each 9.78 feet of travel, the next light will come on and the immediately back of it will turn off. When the cane leaves carrier C3W, the last light (LED 9) will turn off and the sample-in-transit light (LED 3) will turn on indicating that a juice sample is now on its way to the laboratory.

When the proper time for transfer of the juice sample from the mill to the lab has expired, the sample valve will open and its LED 1 will turn on. At the time that the sample jar is filled, LED 1 will turn off and the sample counter count will step up one count.

Since the various LED's indicate at all times how many cane trailer loads are on conveyors C1W and C3W and whether there are juice samples in transit, the juice sampling operator can check the operation at any time since the ticket counter reading must equal the sample counter reading plus cane and juice lights on. Both counters are resettable and are set to 0000 every morning, just before the first trailer load reaches the dumper station.

Fig. 2 is a block diagram of the system. The first sampler was built during the summer of 1973 and was put in service for that year's crop season. It has been in service since then, operating satisfactorily. Then in 1975, when a new tandem was installed to increase our grinding rate to 20,000 tons per day, a second sampler was built following the original design and incorporating the required changes to conform to the conveyors layout and mill-laboratory relative positions. This second sampler, which we call West Mill juice sampler, has been in operation for the last two crop seasons and has performed just as well as that for the East Mill. Maintenance of the system is limited to cleaning of switch C-1 and the juice strainer at the first mill.

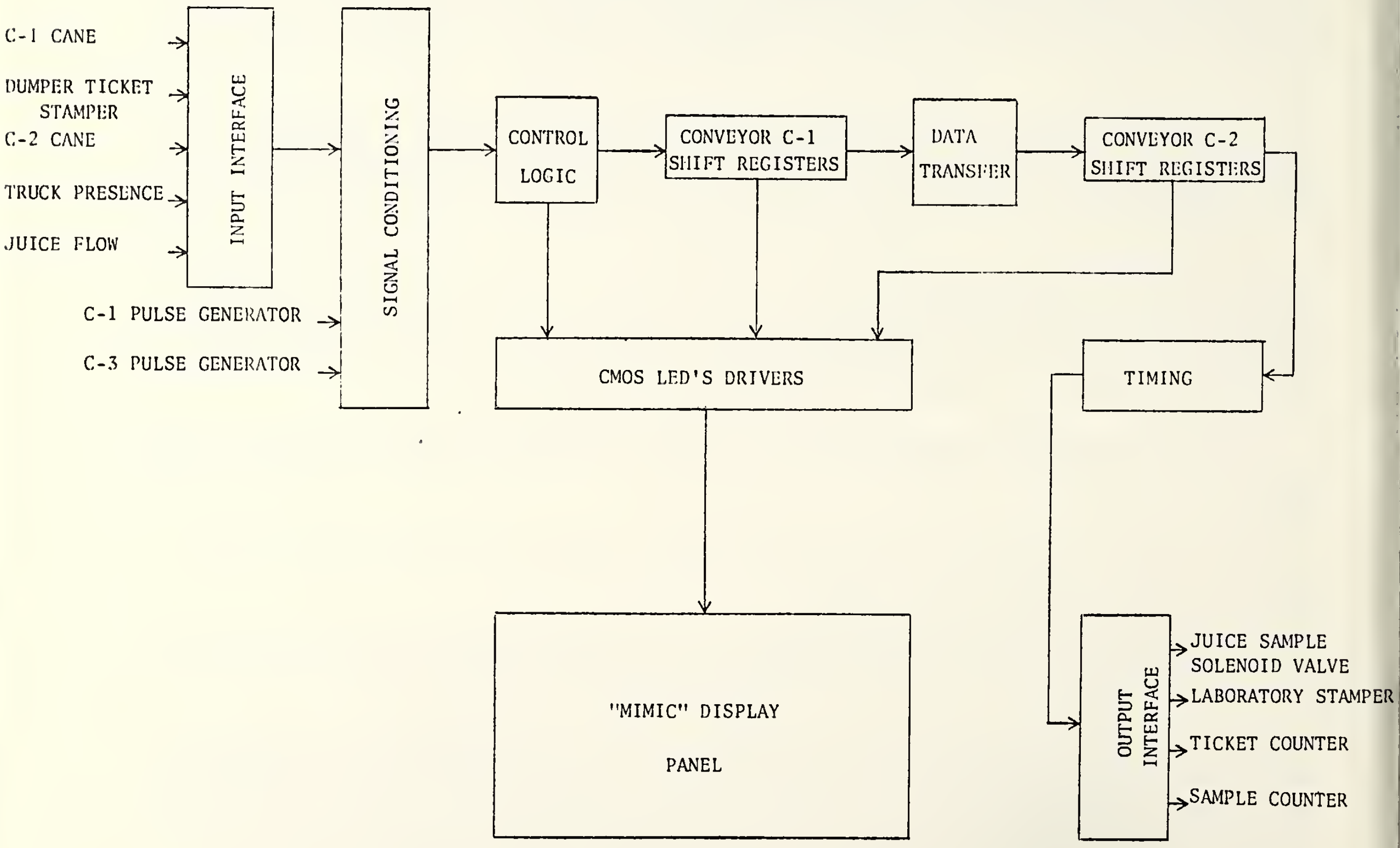

Fig. 2. Electonic juice sampler block diagram.

SOME NOTES ABOUT FUEL ECONOMY IN THE RAW SUGAR FACTORY[1]

Domingo Isasi-Batlle and John Copes
St. James Factory
St. James, Louisiana

ABSTRACT

Prior work done in sugar technology has formulated thoughts to improve fuel combustion resulting in the more economical production of steam. The authors have moved their efforts to the other side of the problem: the utilization of heat in excess process steam and the conservation of high and low-pressure steam resulting in minimizing the use of auxiliary fuels in steam generation.

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[1] Only the Abstract of the paper was available for the Proceedings.

SUGARCANE VERSUS CORN VERSUS ETHYLENE AS SOURCES OF ETHANOL FOR MOTOR FUELS AND CHEMICALS

Edward S. Lipinsky
Battelle, Columbus Laboratories
505 King Avenue
Columbus, Ohio

ABSTRACT

Ethanol production costs using sugar cane, corn and ethylene were estimated and compared. The costs are nearly equal when sugar cane is U.S. $66 per metric ton (dry weight), corn is $100 per metric ton (dry weight) and ethylene is $264 per metric ton. The value of the by-product sugar cane stillage is critical to sugar cane's prospects, but unknown. Acceptance of ethanol-gasoline motor fuels depends more on tax-policy decisions than on technical considerations. Acetic acid and acetaldehyde are more promising uses than ethylene.

INTRODUCTION

The development of fuels and chemical feedstocks from renewable resources is a major objective of the Fuels From Biomass Program recently initiated by the Division of Solar Energy of the Energy Research Development Administration (ERDA). Battelle's Columbus Laboratories has conducted a systems study for ERDA of sugar crops (1) and corn (2) to determine which crops, cultural practices, conversion processes, and energy-rich products merit development. As shown in Fig. 1, the research has many ramifications which transcend the specific topic selected for discussion in this paper. Briefly, the University of Florida, Louisiana State University, and the USDA Houma Laboratories are investigating closely spaced sugarcane as a means of yield improvement. Texas A & M and LSU are investigating sweet sorghum. The University of Puerto Rico is investigating tropical grasses, other than sugarcane and sweet sorghum. The Audubon Sugar Institute and F. C. Schaffer and Associates are researching whole-plant processing and the energy requirements for conversion to ethanol. Joseph Atchison and Associates has initiated an objective evaluation of the Canadian Separator Equipment Process, a new means to obtain sugar and fiber from cane. These diverse activities are coordinated by Battelle which is interpreting results from an energy viewpoint and conducting some of the investigations. Although ERDA is providing the baseload funding, many of these organizations are supplementing this seed money with their own funds.

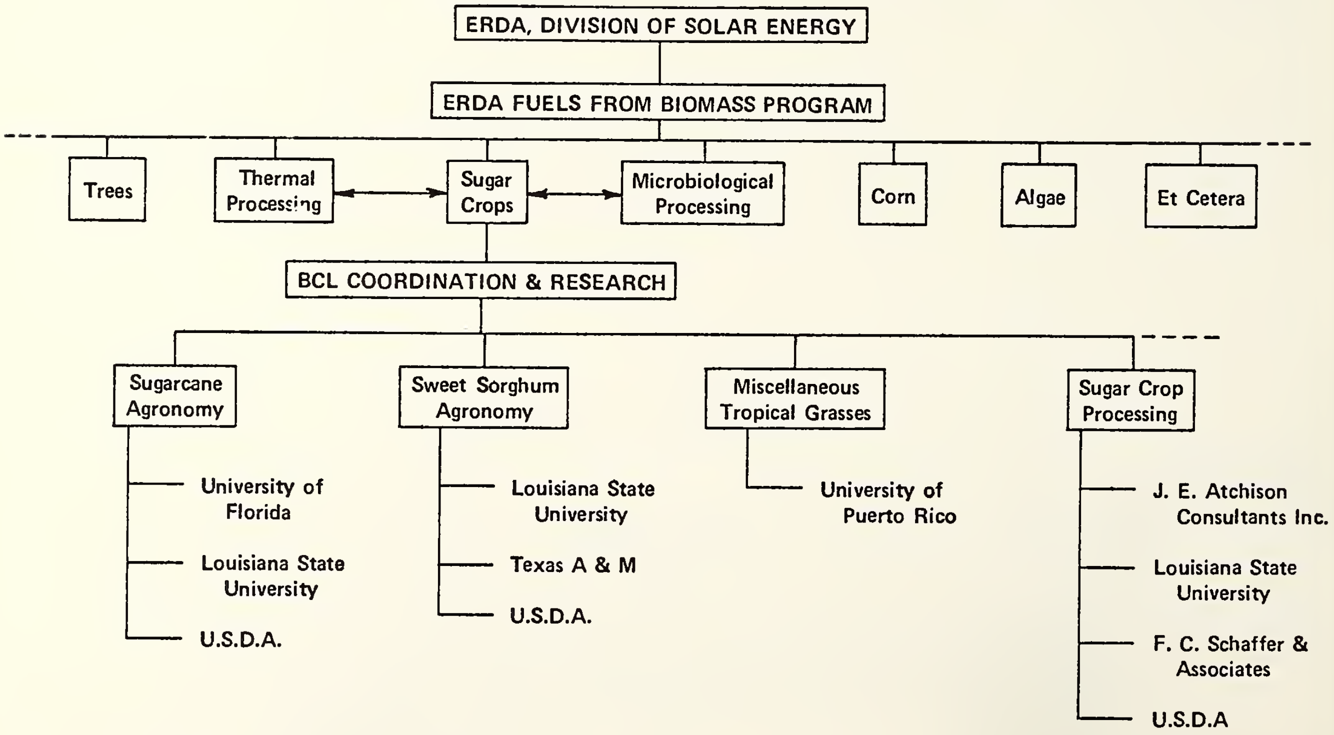

ERDA, DIVISION OF SOLAR ENERGY
ERDA FUELS FROM BIOMASS PROGRAM
Trees
Thermal Processing
Sugar Crops
Microbiological Processing
Corn
Algae
Et Cetera
BCL COORDINATION & RESEARCH
Sugarcane Agronomy
Sweet Sorghum Agronomy
Miscellaneous Tropical Grasses
Sugar Crop Processing
University of Florida
Louisiana State University
U.S.D.A.
Louisiana State University
Texas A & M
U.S.D.A.
University of Puerto Rico
J. E. Atchison Consultants Inc.
Louisiana State University
F. C. Schaffer & Associates
U.S.D.A

Fig. 1. Structure of ERDA sugar crops program.

This paper concerns only one aspect of ERDA's interests in sugar crops but it is the one that is considered the greatest near-term opportunity for the sugar industry. The idea is to use sugarcane juice or molasses as the raw material to manufacture ethanol which is presently made from ethylene. Ethylene now is made either from natural gas liquids or from petroleum products. Fermentation ethanol can be used either as an industrial chemical or as a motor fuel, depending on economic and institutional considerations.

The initial research indicates that attainment of low-cost ethanol is facilitated by the presence of bagasse that can be used as the fuel to distill ethanol. Thus, the ethanol concept has the potential for energy self-sufficiency. Furthermore, the sale of stillage, cane fiber, or electricity could provide by-product credits to keep the cost of ethanol down.

ETHANOL FROM ETHYLENE

To determine under what circumstances sugar-derived ethanol can become a success, one should investigate the economics of the route that provides almost all of the present U. S. industrial ethanol supply. The reaction of ethylene with water in the presence of a catalyst yields one gallon of 95% ethanol for each 4.2 lb of ethylene. The sensitivity of ethanol selling price to changes in the price of ethylene is shown in Fig. 2. Because the yield of ethanol from ethylene is very high and the equipment to effect this transformation is quite simple, one deduces that the present selling price of \$1.22 per gallon (3) includes considerable marketing, technical service, distribution, and profit. The manufacturers of petrochemical ethanol make their own ethylene and use much of their ethylene for production of polyethylene, vinyl chloride, or styrene. Therefore, they have the opportunity to expand their ethylene capacity indirectly by making part of their ethanol from fermentable sugars. This opportunity is to be distinguished from direct entry into the ethanol business by additional companies with a fermentable sugars raw material base.

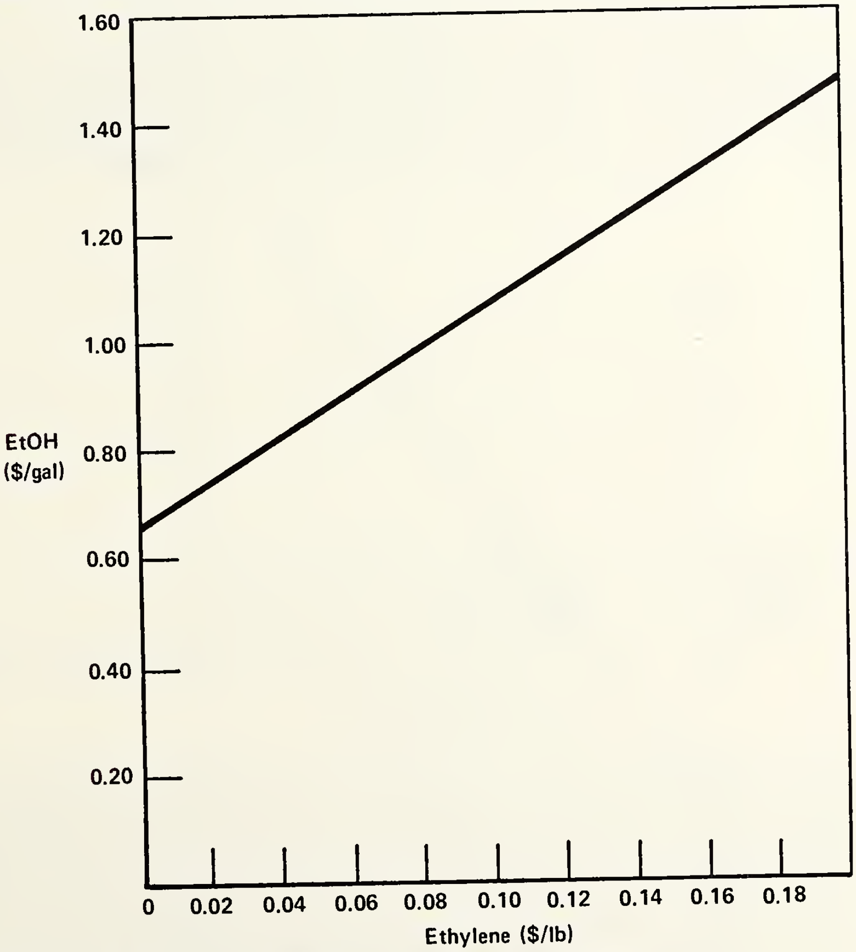


Fig. 2. Ethanol selling price as a function of ethylene raw material cost.

The major ethanol producers recently raised the price approximately \$0.08 per pound to \$1.22. Before the oil embargo, ethanol sold for approximately \$0.54 per gallon. This increase in price presents a challenge to both the sugar and corn industries to determine whether they can compete.

ETHANOL FROM SUGAR CROPS

Sugar crops could yield various products that have promise as a source of ethanol through fermentation. In 1976, Battelle made some preliminary estimates of the cost of ethanol from sugarcane juice assuming a giant facility that would be capable of making about 25% of the U. S. industrial chemical demand for ethanol. The results are summarized in Table 1. The net cost per gallon, including a 15% return on equity appears to be slightly less than the current selling price of ethanol. The comparison is somewhat one of apples versus oranges because the sugarcane juice-derived ethanol does not include marketing and technical service charges. Nevertheless, it shows that the cost of fermentation ethanol is in the right ballpark.

Table 1. Cost of ethanol from sugarcane juice.

	$/gal
Sugarcane juice	0.81
Operating costs	0.32
Annualized capital charge	0.22
Stillage byproduct credit	(0.19)
Net cost per gallon	1.16

Source: Battelle estimates, (Reference No. 1).

The sensitivity of ethanol costs to the cost of fermentable sugars is shown in Fig. 3, with the assumption that the by-product stillage could be sold for $60 per ton. Low-cost sugarcane juice (around $0.06 per pound) might become available at a facility that did not invest in evaporation and crystallization equipment and which could use sugars from cane harvested after damage by adverse weather. However, these costs are not likely to be highly attractive to the sugar industry for facilities that have already been built. The sugarcane is assumed to be available for approximately $16 per ton (28% solids).

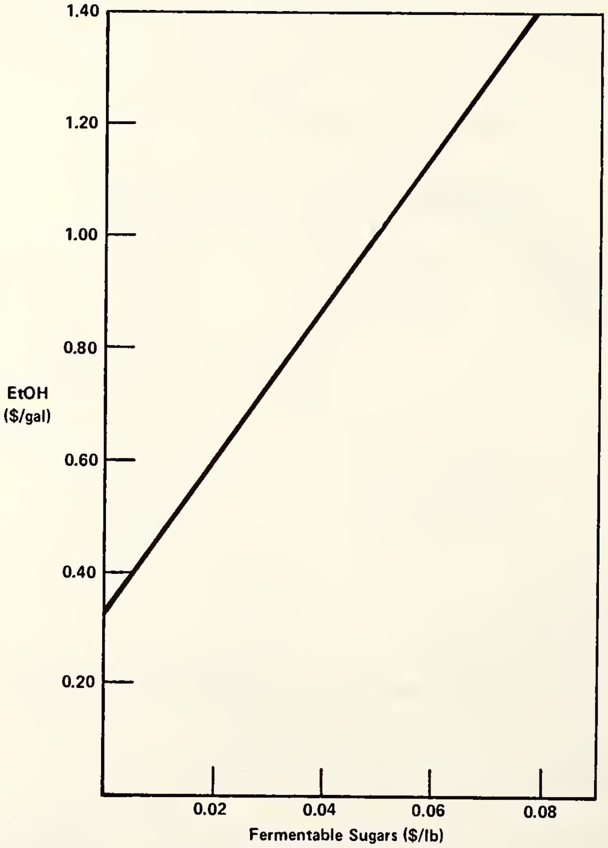


Fig. 3. Ethanol cost as a function of fermentable sugars cost.

The impact of stillage selling price on the net cost of ethanol is considerable. This by-product results from evaporation and drying of the solids obtained from distillation bottoms. The comparable product from corn mash (see below) has a high protein content, high vitamin content, and low salt content. Unfortunately, the sugarcane-derived stillage has half of the protein content of corn stillage, about the same vitamin content, and about five times the salt content. The result is a by-product from sugarcane juice that is believed to be not much more than 50 percent of the value of that derived from corn. This impact is shown in Fig. 4. A major uncertainty in the prospects of ethanol from sugarcane is the value of this stillage.

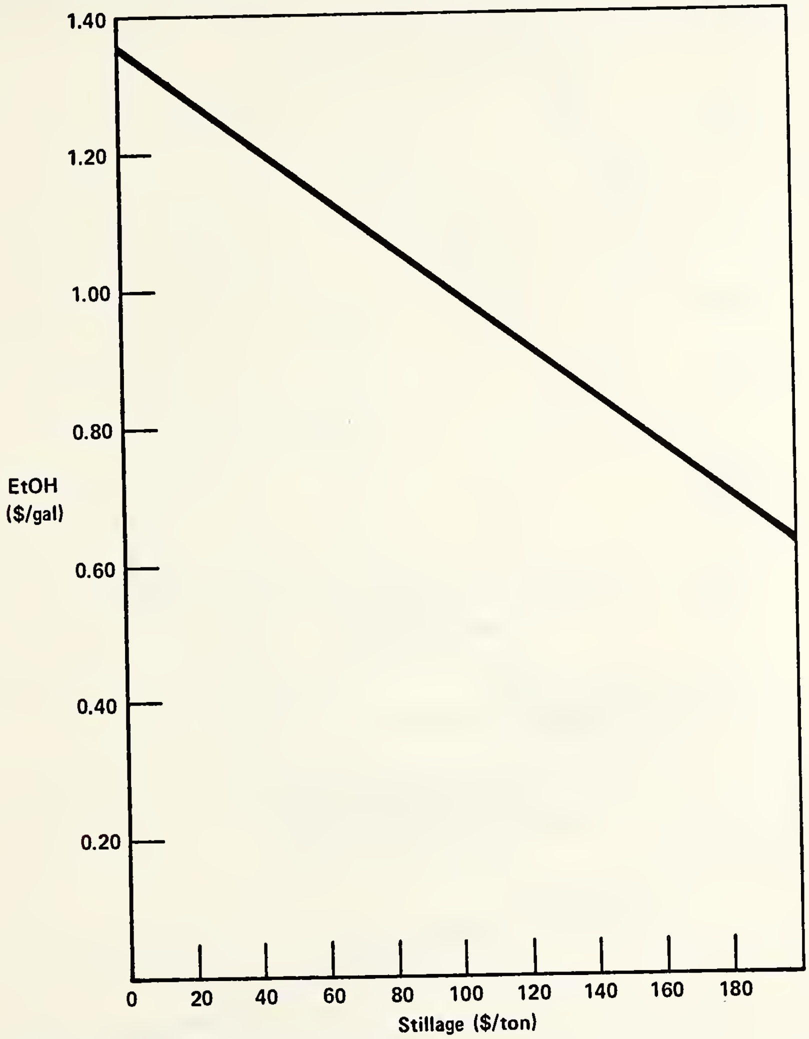


Fig. 4. Ethanol cost as a function of stillage selling price.

ETHANOL FROM MOLASSES

The F. C. Schaffer Company and Louisiana State University are collaborating with Battelle in a study of ethanol, as noted previously. At the conclusion of these studies, a definitive paper will be presented. However, we wish to alert the sugar industry to desirable aspects of ethanol from molasses at the earliest possible time. Therefore, I take this opportunity to present some preliminary information on this subject. If one takes what appears to be a conservative position with regard to annualized capital charges and operating costs and if one assumes the production of one gallon of ethanol from 2.5 gallons of molasses, it appears that ethanol could be made from molasses for less than $1.10 per gallon (Fig. 5), even if the stillage credit were zero. If stillage from the molasses process has some value (Fig. 6), the net ethanol cost drops appreciably. For example, if the $60 per ton stillage value assumed for the sugarcane case applied also to molasses, the selling price of ethanol could be as low as $0.87 per gallon. Even when 10 percent marketing charges are added, the ethanol would still cost less than $1 per gallon in this very preliminary estimate. Thus, manufacture of ethanol from molasses merits very serious consideration.

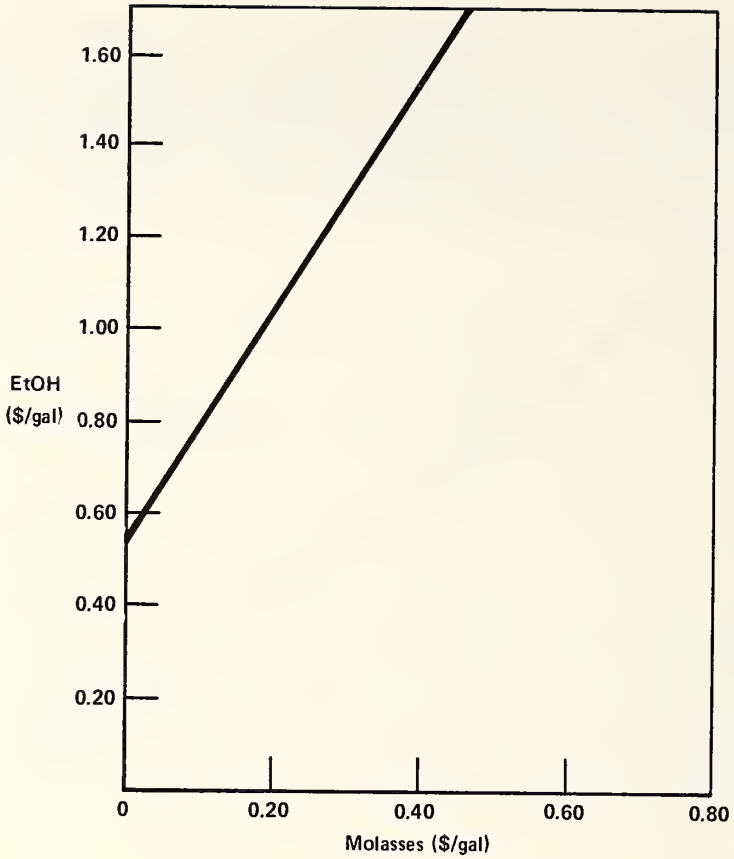


Fig. 5. Ethanol cost as a function of molasses cost with zero stillage credit.

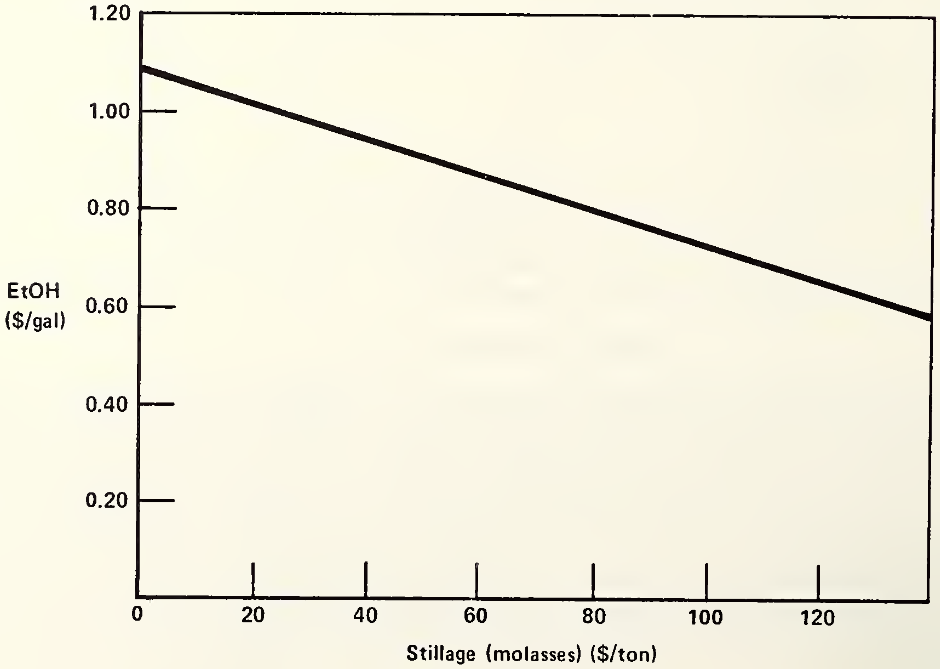
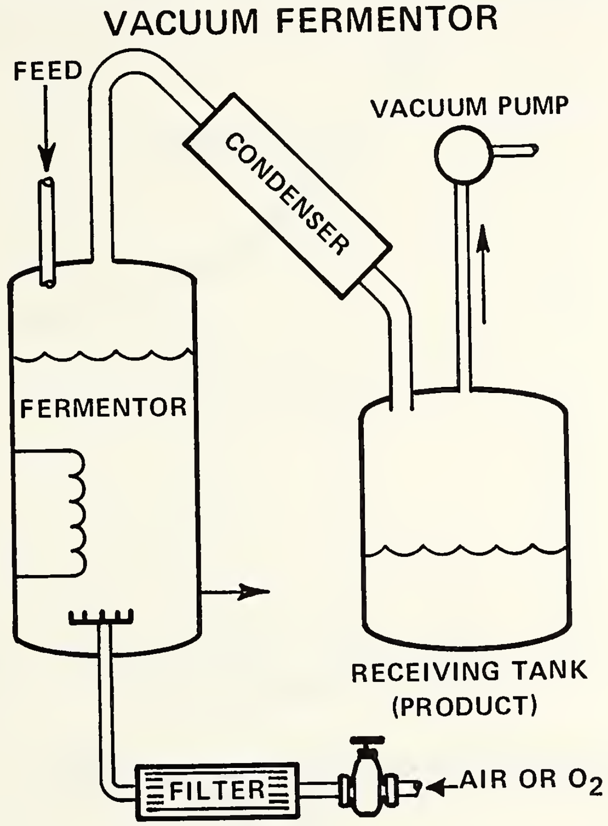


Fig. 6. Ethanol cost as a function of stillage credit (molasses).

ERDA has under development some new technology which pertains to ethanol from molasses. Professor C. R. Wilke of the University of California at Berkeley is developing a vacuum fermentation process that requires less fermenter capacity and less energy for its operation (4). A simplified view of this approach is provided by Fig. 7. By operating the fermentation in a vacuum, the fermentation time is reduced to 8-12 hours from 50-70 hours. The ethanol can be distilled when its concentration rises into a range that would otherwise slow down the yeast conducting the fermentation. Aside from the advantage of conducting the initial distillation at a lower temperature, the vacuum fermentation process also permits use of much more concentrated solutions. As shown in Fig. 8, the University of California research (4) indicates that the cost of vacuum fermentation declines considerably as one moves from the sugarcane juice level of concentration (10 to 15% solids) to that of molasses that has been diluted somewhat (30-40% solids).



SOURCE: Adapted from G. R. Cysewski and C. R. Wilke, March, 1976.

Fig. 7. A vacuum fermentation process.

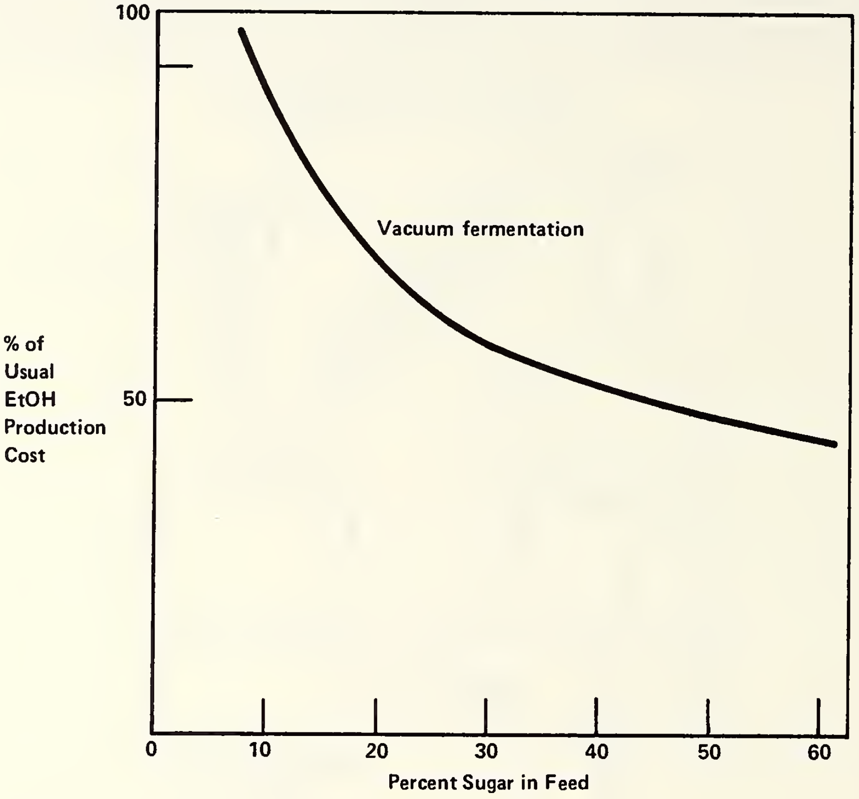
Although the vacuum fermentation process is in the early stage of development, it promises to reduce both the capital and operating costs of ventures to make ethanol from molasses. Comparable savings would not be available for sugarcane juice or glucose derived from enzymatic hydrolysis of cellulose.

ETHANOL FROM CORN GRAIN

It is not sufficient that molasses or sugarcane juice might yield ethanol at a lower cost than ethanol from ethylene. Corn-based ethanol might be even cheaper. Certainly, there is much more corn grain available in the United States than molasses or sugarcane juice. Battelle investigated the possible cost of ethanol from corn grain in a preliminary fashion. The Battelle estimates (Table 2) took into account the published work of Miller (5) and Scheller (6).

The key factors in ethanol from corn costs are the very high by-product feed credits based on the well established stillage by-product (distiller's dried solubles with grain), and a relatively high conversion cost that results from the need to degerm and mash the corn.

The net cost of ethanol from corn grain is almost identical with that of ethanol from sugarcane juice but is somewhat higher than that estimated from ethanol from molasses. The sensitivities of ethanol costs to the cost of corn grain and to the stillage by-product credit are shown in Fig. 9 and 10. The food uses for grain are likely to keep costs of corn-based ethanol above the $1 per gallon level. However, the introduction of vacuum fermentation could reduce the cost of ethanol from corn grain because the same enzyme hydrolysis that makes glucose and subsequently high fructose corn syrup could be used to make relatively concentrated solutions of corn syrup that would behave like molasses in the vacuum fermentation process.



Source: Adapted from G. R. Cysewski and C. R. Wilke, March 1976.

Fig. 8. Cost of fermentation as a function of fermentable sugars concentration.

Table 2. Cost of ethanol from corn grain.

	$/gal
Corn at $2.50/bushel	0.89
Conversion cost	0.44
Annualized capital charge	0.20
By-product feed credit	(0.36)
Net cost per gallon	1.17

Large scale corn processors have options other than sole production of ethanol and corn stillage. They can manufacture ethanol, corn starch, and animal feed ingredients. They also can manufacture ethanol, high fructose corn syrup, and animal feeds. Such processes are believed to allow allocation of costs such that the ethanol would be substantially cheaper than the case considered here (2). However, the quantity of ethanol that can be produced at a given location is diminished in proportion to the amount of potentially fermentable material that is diverted to higher priced products.

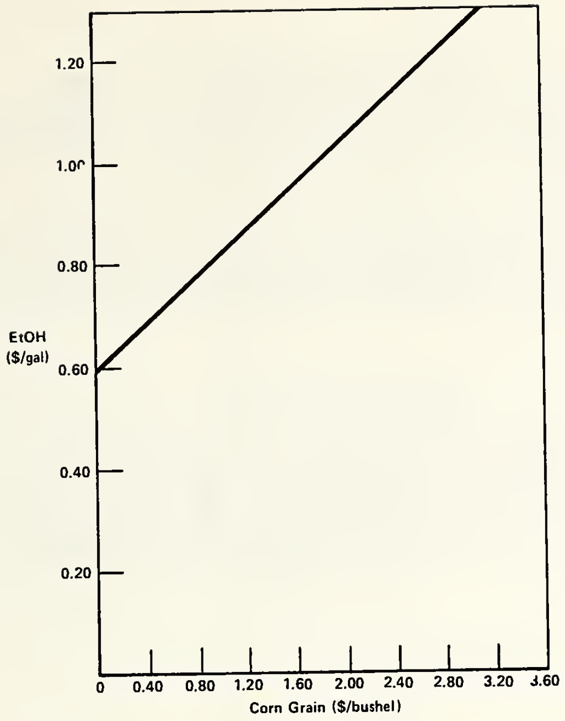


Fig. 9. Ethanol cost as a function of corn grain cost.

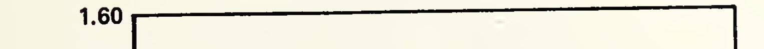


Fig. 10. Ethanol cost as a function of corn stillage credit.

WHICH RESOURCE WILL WIN?

It is much too early to name a winner in a race of this nature. Molasses appears most attractive for small ethanol plants. Corn grain may have the advantage for giant ethanol plants. An ethanol plant should be operated through as long a season as possible as it probably is not economic to evaporate sugarcane juice for use in the off-season.

The potential advantage of ethanol production as a means to siphon off temporary surpluses that usually reduce agricultural commodity prices is an interesting aspect. Unfortunately, ethanol production facilities are too expensive to build for use on a standby basis when the price of sugar goes too low. However, much of the same effect could be accomplished if variable quantities of sugarcane juice are used to supplement molasses for ethanol production.

CHEMICALS FROM ETHANOL

Three high-volume chemicals that might be manufactured from ethanol are ethylene, acetic acid, and acetaldehyde (see Fig. 11). Ethylene is one of the major building blocks of Western Civilization. However, its molecular weight is only 28 while that of ethanol is 46. This immutable chemical fact is translated into economic terms as follows: about 1.6 pounds of ethanol are needed to produce 1 pound of ethylene. This is a very great burden for ethylene to bear and generally results in quite high costs, regardless of the efficiency of the conversion process. For example, Battelle has estimated that ethylene would cost at least $0.28 to $0.30 per pound when made from ethanol that is valued at $1.15 per gallon.

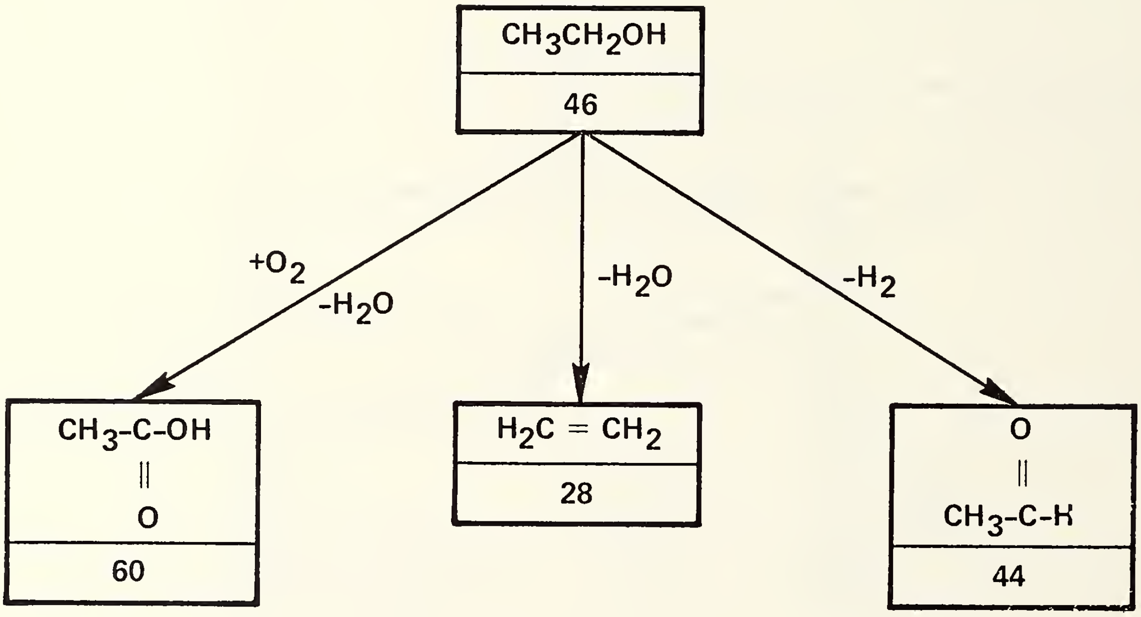


Fig. 11. Several chemicals derived from ethanol.

In contrast to ethylene, acetic acid has an appreciably higher molecular weight than does ethanol. The result is that each pound of acetic acid needs only about 0.75 lb of ethanol for raw material. The increase in molecular weight during acetic acid production arises from oxygen from the air and thus ethanol is a relatively attractive source of acetic acid.

Acetaldehyde has virtually the same molecular weight has ethanol and thus is neutral with regards to its prospects. In this instance, the efficiency of the processing method is the key factor.

These simple considerations leads one to conclude that acetic acid from sugars merits more attention than does acetaldehyde which in turn merits more consideration than does ethylene.

ETHANOL AS A MOTOR FUEL

The pioneering research in Nebraska (6, 7) and the ambitious program for ethanol motor fuel in Brazil (8) are demonstrations of the technical practicality of gasoline/ethanol blends. The American Petroleum Institute committee report (9) on ethanol motor fuel blends expresses opposition to these blends and introduces an element of controversy. We have performed a few calculations and observations that bear on these issues.

As shown in Table 3, Nebraska's ethanol can be considered to be worth its full selling price, according to Scheller's analysis. The analysis is for a 10 percent ethanol/90 percent gasoline mixture. Thus, the displacement of one gallon of no-lead gasoline valued at $0.385 per gallon by ethanol makes the value of ethanol at least $0.385. Then a credit is taken for the octane improvement that ethanol imparts to the gasoline. The mixture of gasoline with ethanol leads to an expansion in volume of the mixture. This expansion serves to allow less fuel to be dispensed in each gallon. A credit is taken for this expansion. Finally, credits are taken for better gas mileage and the Nebraska tax reduction. In all instances, the total value of each benefit is assigned exclusively to ethanol. The overall result is a value for ethanol above the cost calculations for ethanol from either corn or sugarcane.

Table 3. Value of ethanol in gasohol fuel.

	Cents/gal	
	Scheller	Battelle
One gallon of no-lead displaced by ethanol	38.5	38.5
Credit for reduction in no-lead O.N.	18.9	18.9
Credit for expansion of mixture	1.0	1.0
Credit for 5 percent less fuel consumption	32.0	--
	90.4	58.4
Credit for Nebraska tax reduction	30.0	--
Total	120.4	58.4

Source: Scheller (1977) and Battelle estimates

Battelle's alternative evaluation (again, see Table 3) would give credit for the no-lead gasoline displaced using a cheaper blending stock of hydrocarbons to achieve the target octane number, and for volume expansion. These values total approximately $0.60 per gallon. Credit is not given for the 5% less fuel consumption that has been observed in Nebraska because that reduced fuel consumption occurred when ethanol was added to conventional (relatively high octane), no-lead gasoline. Priority should be given to research on the mileage to be expected from blends of ethanol with cheap blending stock. According to Murphy's Law*, it seems unreasonable to expect that one can use both the cheaper blending stock and obtain the better gas mileage. We chose to take the credit for the cheap blending stock because that is a tangible advantage that might persuade a purchasing agent to buy ethanol instead of aromatics. In contrast, five percent better mileage is an advertising claim that is difficult to convert to cash.

In this evaluation, no credit was taken for tax reductions or incentives. Rather, as shown in Table 4, it appears better to observe the impact on the selling price of the no-lead gasoline. The impact is to increase the selling price $0.06 to $0.08 per gallon. Once this impact is observed, the planners for a state, commonwealth, or federal government can determine whether a tax incentive should be applied. The incentive might be to tax the ethanol blends less or to raise the gasoline tax while excusing ethanol blends from part or all of the tax increase. These are political decisions beyond the scope of this paper.

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*"Anything that can go wrong will go wrong."

Table 4. Hypothetical no-lead blends (in cents per gallon).

Cost element	Conventional	10% ethanol with no-lead	10% blend with low octane no-lead
No-lead gasoline	38.5	34.7	32.8
Anhydrous ethanol	--	11.8	11.8
Fuel transportation	3.3	3.3	3.3
Retail station markup	9.3	9.3	9.3
State tax	8.5	8.5	8.5
Federal tax	4.0	4.0	4.0
19xx tax on conventional gasoline	6.0	--	--
Total	69.6	71.6	69.7

Sources: Scheller, 1977 and Battelle estimates

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EXCESS POWER IN SUGARCANE FACTORIES

J. J. Mecsery
Atlantic Engineering, Inc.
Coral Gables, FL

ABSTRACT

The article briefly discusses the potential use of sugarcane and bagasse used today as fuel. It describes two cycles in two sugarcane factories where commercial quantities of excess power are being generated without the use of auxiliary fuel. The two cycles described are entirely different; one uses a duel inlet pressure auto-extraction turbine, while the other uses a top auto-extraction turbine. The three-arm regulator, or heart of the control of an automatic extraction turbine, is described and illustrated diagrammatically. Finally, the author urges designers to consider this valuable and proven way to save energy in the development of the new sugarcane factories.

Every day in our sugarcane industry management is becoming more concerned about greater utilization of energy from all fuels including the bagasse which is the main source of energy for the industry. Rising cost of fuel oil and other fuels has brought attention to the value of bagasse as a valuable fuel.

The use of bagasse as a fuel to generate steam which in turn moves the prime movers of the mill and generates the electricity necessary for processing is very common to all in the industry. What is not common is the better utilization of the fuel to generate extra power for sale to public utility systems. It is possible in many sugarcane factories to generate extra power for sale during the grinding season without any extra fuel.

There are only a few sugarcane areas where the increase of electric energy production from available bagasse has reached a high level, one being Hawaii, the one that has reached almost optimum conditions. Better utilization of the fuel does not necessarily mean the increase of combustion efficiency. Greater utilization means that it is necessary to increase the efficiency of the entire plant including the boiler's efficiency and aquisition of the additional equipment required to generate the extra power as well.

Each plant that desires to generate extra power would need a tailor made steam power cycle and equipment. The amount of extra power a particular sugarcane factory can generate will depend on many factors; these include the amount of cane ground, length of the crop, fibre content in cane, special requirements due to by-product plant, pressure and temperature of generated steam, etc.

The intention of this paper is to illustrate the means by which extra power is generated. Two cases are presented to illustrate how this has been accomplished. In both cases the author participated in the design, installation, and operation of these plants. In all these cases it was necessary to use higher steam pressure and temperature, the use of extracted steam for feedwater heating, higher boiler efficiency, heat conservation use in factory operation, and use of modern instrumentation for easy operation and stability. The two cases that I will describe are in typical sugar factories in Cuba with existing low pressure water tube boilers and a few fire-tube boilers. In both cases new boilers and turbo-generators operating at higher pressure and temperature were installed.

Case I. This case, illustrated in Fig. 1, was installed at Central Hershey (Camilo Cienfuegos), Cuba. One topping auto extraction turbo-generator, two high efficiency bagasse burning boilers and one deaerating heater and auxiliaries were the main new equipment installed.

The boiler steam pressure was 400 psig., 750 F.T.T., the automatic extraction steam was maintained at 135 psig. and the temperature maintained about 50 F superheat (50 above saturation). All the steam extracted went to the existing low pressure prime movers. The amount of steam extracted was approximately 200,000 lb/hr. This steam plus the small amount that went to the deaerator and condensers was responsible for the generation of 5,000 kw per hour delivered to the utility system almost at a constant rate for the entire duration of the crop as extra or excess power.

The desuperheater was necessary to limit the steam temperature to 50 F above saturation so that it can be used in the old existing turbines and engines that were designed for 125 psig. saturated. The boilers are made high efficiency by the use of a large air heater, water walls, good wall insulation, and suspension burning of bagasse which contributed to low excess air (less than 30%) and fast response to load changes giving the boilers the ability of full automation. The turbo-generator is a multi-stage condensing unit with one auto-extraction at 135 psig. and one un-controlled extraction for feedwater heating. This installation represented a sound investment because it was recovered in just a few years of operation.

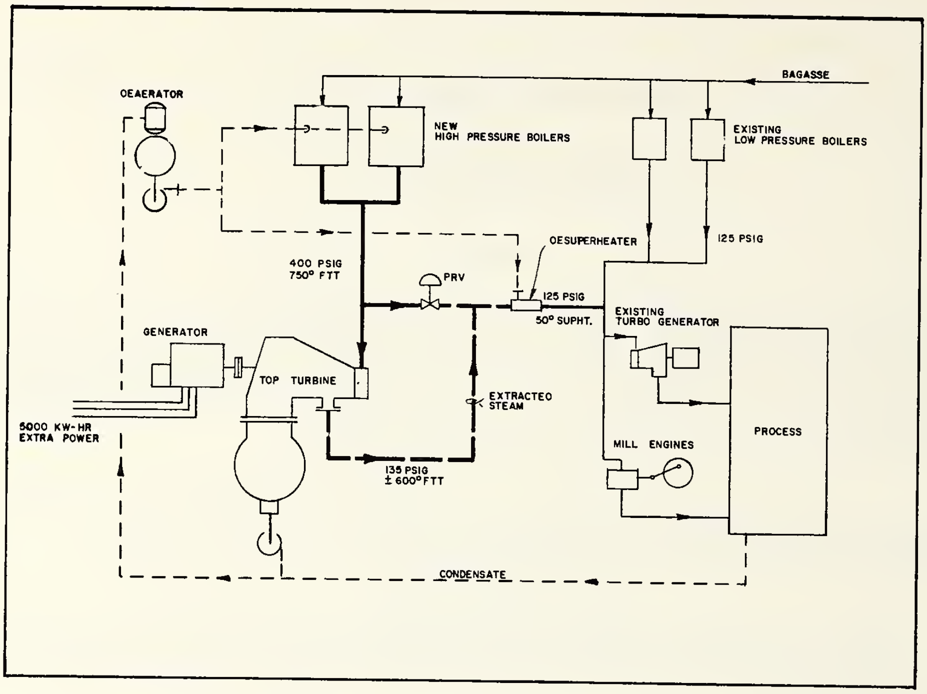

Fig. 1. Case 1 - Topping turbo-generator.

Case 2. Fig. 2 illustrates this case. The equipment was installed at Central Delicias Oriente, Cuba; here the major equipment installed were:

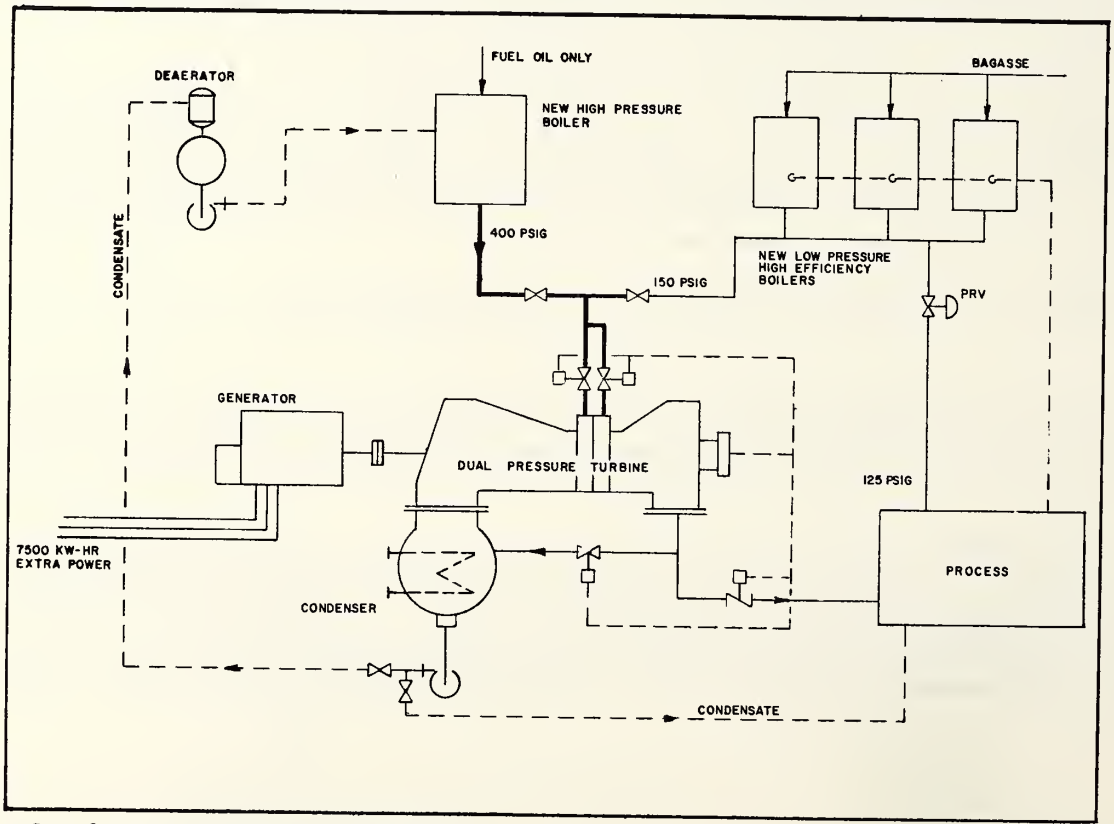

Fig. 2. Case 2 - Dual pressure turbo-generator.

one large high pressure and temperature boiler for burning fuel oil only, several high efficiency boilers to burn bagasse and one deaerating heater and one dual pressure, (400 psig. and 150 psig.) auto-extraction turbine. The most important equipment of this cycle is the special dual pressure auto-extraction turbine. This turbine is actually two turbines, one of high pressure and one low pressure on a common shaft connected to one generator. This was selected due to the fact that in this factory the power plant was also the utility company serving electric power to nearby cities and communities year around without any tie to any other electric plant.

During the crop season (almost 5½ months) the turbine operated at low pressure 150 psig. During this time the turbine operated at maximum extraction; a small steam flow toward the condensers (high pressure section) was necessary to keep the blade cool. The steam was extracted at approximately 18 psig. and used for processing. New high efficiency bagasse burning boilers were installed and as in Case 1, these were equipped with water walls, air heaters, and suspension burning. With all new equipment installed it was possible to deliver 5000 to 7000 kw-hr of excess power generated to be used in the utility system.

During the idle season the turbo-generator works in a closed cycle using high pressure steam, 400 psig. 750 F going to the condenser, except that extracted for heating and a small amount through the low pressure section to cool the blades. During this time the boiler used is a modern, high efficiency boiler burning only fuel oil.

The three arm regulator is the heart of the automatic extraction turbo-generator. The regulator makes it possible for the automatic extraction turbine to maintain constant extraction pressure while the electric load changes. This regulator is illustrated in Fig. 3. When there is a change in load, the centrifugal speed regulator moves both the inlet and extraction or diaphragm valves at the same time, correcting the load and maintaining the extraction pressure constant. When there is a pressure disturbance in the extraction line, the pressure bellows moves the three arm regulator's vertical arm to reset the inlet and extraction valve in opposite direction to each other. This adjustment makes that extraction pressure remain constant.

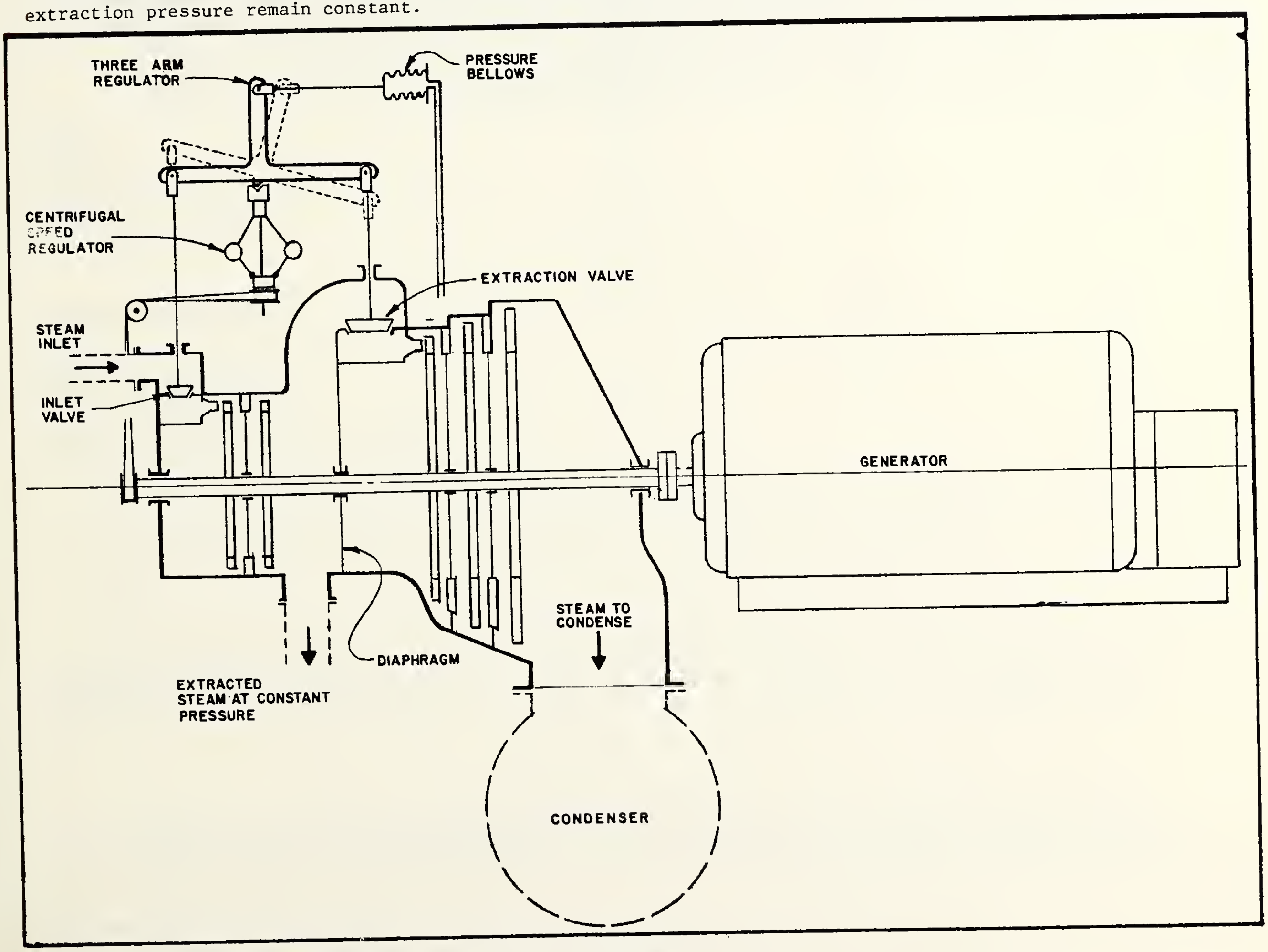

Fig. 3. Three arm regulator for auto extraction turbines.

COMMENTS

There are many ways in which the equipment can be combined to form an efficient cycle. The many choices of steam pressure and temperature make the selection almost infinite. In old factories the pressure and temperature of existing equipment necessarily remains the same. In new factories the designers have a free choice for the pressure and temperature for the new and future equipment. This is where the author urges the designer working on new sugarcane factories to consider in every possible case a future addition of an efficient cycle to generate extra power that can provide additional income and in addition to use a more efficient cycle that will prove beneficial for the area (or country) in offsetting the cost of imported fuel.

The amount of electric power generated for their use in a totally electrified (except mills) raw sugarcane factory is about 15 kw-hr/ton cane/hr (Hugot page 814) or equivalent to 60 kw-hr/ton bagasse. The amount of extra power can be in the order of 140 kw-hr/ton bagasse or more.

All this has been proven in Hawaii where more than 220 kw-hr/ton of bagasse has been achieved with a similar cycle described earlier in Case 1, using a top unit.

As a matter of interest, I would like to quote the following from Powers Editorial of June 1977 issue:

"CONGENERATION.-

The simultaneous production of steam for process and electricity--with the excess of electricity at any time of day made available to the local utility grid--was proposed by President Carter for many industrial sectors. Although it is becoming increasingly attractive as energy prices rise, some institutional barriers crop up impeding its full development. The President's National Energy Plan proposes to remove those barriers by assuring that industrial firms generating electricity receive fair rates from utilities for both the surplus power they would sell and for the backup power they would buy. It is further proposed that industries using congeneration to produce electricity could be exempted from state and federal public utility regulation, and would be entitled to use public utility transmission facilities to sell surplus power and buy backup power when needed. An additional tax credit of 10% above the existing investment tax credit, would be provided for industrial and utility cogeneration equipment."

SAVING ENERGY IN SUGAR MILLS

J. A. Polack and H. S. Birkett[1]
Audubon Sugar Institute
Louisiana State University
Baton Rouge, Louisiana

ABSTRACT

Saving energy and natural gas is the number one technical, and perhaps economic, challenge to domestic cane sugar processors. Louisiana mills alone are consuming over 6 million MCF of gas annually, at a cost of over $10 million. While Florida mills are generally more modern and efficient, their fuel oil cost is about $7 million. Energy may be saved 1) in the steam generation plant and 2) in the mill and boiling house. This paper examines those areas where losses occur and where improvements should be possible. Areas for savings include: a) reduction of excess air in furnaces, b) recovery of waste heat in stack gas, via air preheating or bagasse drying, c) reduction of unburned combustibles, d) raising boiler and turbine ring pressures, and e) balancing of high pressure and exhaust steam requirements. Future investments could become necessary in improved firebox designs, heat recovery equipment, instrumentation for optimum control, higher pressure boilers, and additional evaporator effects. Ultimately, energy self-sufficiency--i.e. freedom from dependency on fossil fuels--should be an attainable goal.

INTRODUCTION

Saving energy or reducing natural gas (or other supplementary fuel) usage is the No. 1 technical challenge in the raw sugar industry. Ever-rising fuel prices and the prospect of allocations may also make fuel self-sufficiency the primary economic challenge to the industry. The following figures show the supplementary fuel consumption and the corresponding costs in Louisiana and Florida.

Louisiana
(22 mills that sold no bagasse)

Season	1974	1975	1976
Natural gas use, MCF/ton cane	0.8	0.5	0.6
Typical cost, $/MCF	0.96	1.32	1.75
Fuel cost, $/ton cane	0.81	0.66	1.05

Florida

Season (starting date)	1974	1975	1976
Fuel oil use, gal/ton cane 1/	2.4	1.9	--
Typical cost, ¢/gallon	27	29	34
Fuel cost, $/ton cane	.65	.55	--

1/Data from Gilmore Manual for 1976.

Auxiliary fuel use in Florida is only about half that of Louisiana mills, but since fuel oil is more expensive than gas (on a Btu basis), the costs per ton of cane are almost as high.

This paper presents an overview of the present situation and suggests measures that will have to be taken.

With existing technology, it is possible and economically feasible to design a new sugar factory that would be energy self-sufficient. The problem, therefore, is not so much with the state of technology as it is with what can be done in existing factories, working with limited budgets. This paper will present the fuel savings possible by various changes in equipment and operating practices.

Energy Balance

Clean Louisiana cane contains about 12% true fiber, while in Florida it runs about 10%. The gross (higher) heating value of bagasse fiber is taken as 8300 Btu/lb. A summary of the energy available from bagasse and the energy required to operate Louisiana and Florida sugar factories is given below.

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[1] Present address: F. C. Schaffer and Associates, Baton Rouge, LA.

State	Bagasse fuel value, btu/ton cane	Steam requirement, lb/ton cane	Energy required for steam generation, btu/ton cane
Louisiana	1,992,000	1200-1600	1,200,000-1,600,000
Florida	1,660,000	800-1200	800,000-1,200,000

Thus, for the Louisiana factories using the least quantity of steam a boiler efficiency of 60% would be required for fuel self-sufficiency. The Florida mills, despite lower fiber, are generally more recent and modern; for them, a boiler efficiency of about 50% would be needed for fuel self-sufficiency.

In Louisiana, the typical sugar factory has a boiler efficiency of only 45%, while in Florida, the boiler efficiencies are about 5-10% higher.

Areas for Improvement

Basically, there are three areas for seeking improvement:

1. Improving the quality of the bagasse sent to the boilers.
2. Improvements to the furnace, boiler, and operating performance of the boiler plant.
3. The reduction of the steam required for operating the mill and boiling house.

Items 1 and 2 above will result in more live steam production, while item 3 will reduce the need for steam. In general, it is preferable to attack the problem from all angles, since improvement in any given aspect soon reaches the point of diminishing returns, and reveals new limitations elsewhere.

Improving the quality of the bagasse fuel

The quality of the bagasse is dependent on:

1. Its ash content.
2. Its moisture content.

Bagasse ash content: A high bagasse ash content has two deleterious effects:

1. It absorbs juice and therefore increases the effective moisture of the bagasse. For example, a bagasse containing 10% ash and having a moisture of 55%, is thermally as bad as an ash-free bagasse having a moisture content of 62%.

2. The ash in the bagasse is incombustible and therefore has to be removed from the furnaces. In the case of pile-burning furnaces, this increases the frequency of the cleaning cycle. Cleaning cycles are periods of low boiler efficiency, since the air excess is increased and since bagasse fuel is lost with the ash.

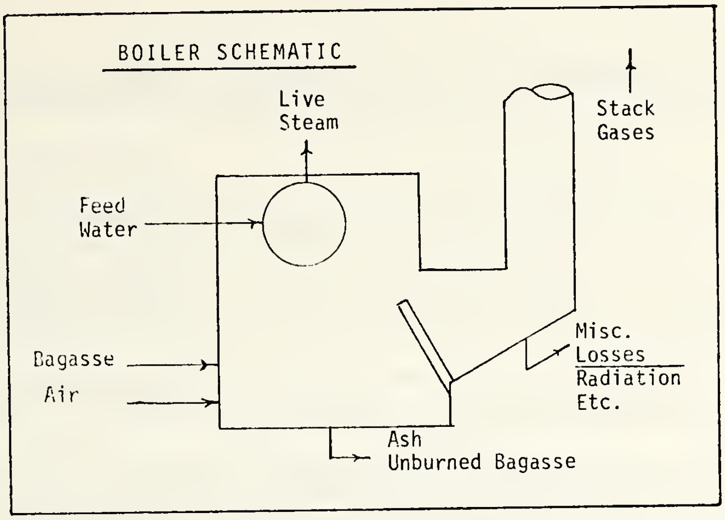
The new improved 45°, thin mat, high speed, cane-washing tables do a much better job of washing the cane than the older cane-feeding tables that have been converted to cane-washing. Apart from the cleaner bagasse, the cleaner cane reduces mill wear and may permit lower bagasse moistures and improved mill extraction. For a factory grinding 3000 tons of cane per day, these newer tables cost about $125,000.

Bagasse moisture content: The moisture in bagasse lowers its heating value, and reduces the furnace temperature, which in turn decreases the rate of burning. It appears that a greater quantity of excess air is required to burn a high moisture bagasse, and thus the boiler efficiency is further reduced.

Boiler Plant Improvement

In proper boiler operation, the maximum potential heat in the bagasse is recovered in the steam. Typically considered good efficiency is 60%. But many Louisiana mills run around 45%.

The biggest waste is out the stack. The reduction of the stack gas losses, and the recovery of this heat is a most obvious approach.



The limiting of the excess air to that required for complete combustion is the first step, since the greater the volume of the stack gases the most heat is stolen from the steam. Air is 80% useless nitrogen. So every bit of extra air brings in 80% of this inert material which soaks up heat without yielding any benefit. The following table illustrates this point:

% excess air	% increase in stack volume	% of energy in bagasse out the stack at 600 F
0	0.0	34.0
50	34.5	38.3
100	69.0	42.6
200	138.0	51.3

The remedy here is to tighten up on the air admitted to the fire box and closely monitor the stack gas composition, primarily for oxygen. The carbon monoxide and carbon dioxide contents will, of course, also be useful in analysis of the furnace operation.

Even with good combustion, much heat is lost out the stack. Much of this waste heat can be recovered by using the hot stack gases to:

1. Heat the boiler feed water in finned tube economizers.
2. Preheat the combusion air.
3. Dry the bagasse.

Economizers are most useful when the feed water to the boilers is at a low temperature, and when the steam pressure (and hence saturated steam temperature) is high. Under Louisiana conditions of low steam pressure, and hot, deaerated feedwater, there is little potential for economizers. In Florida, where the steam pressure usually exceeds 250 psig, economizers are particularly useful.

The air preheater provides a good way to recover the heat from the stack gases. There is enough combustion air to reduce the flue gas temperature to less than 300 F, using a relatively small heat transfer area. These preheaters require no additional mechanical accessories other than the heater itself. However, the induced and forced draft fans should be capable of overcoming the additional pressure drop through the air preheater.

Although bagasse dryers were tested as long ago as 1911[2], they did not come into significant commercial use until recently. Theoretically, the bagasse dryer and the air preheater have the same thermal efficiency when operating with the same final stack gas temperature. The bagasse dryer has potential theoretical advantages for achieving somewhat lower stack gas temperature, and may yield some benefit in bagasse burnability. But practical problems with the dryer remain to be overcome. These are:

1. Mechanical power requirements for its operation are greater than those for an air preheater, since additional bagasse conveyors, cyclone separators, etc. are required.
2. Fugitive emissions are difficult to control.
3. The dry bagasse and fines constitute a fire hazard.

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[2] E. W. Kerr, Bulletin No. 128, LSU Agricultural Experiment Station, June 1911.

The first year trials of bagasse dryers in Louisiana have left something to be desired. However, with modifications and experience in their operation, they may become a viable alternative to air preheaters.

Steam Utilization

Next let's look at the mill and boiling house. Assuming that we have done everything to maximize steam production from the bagasse, we will consider what changes can be made to reduce steam consumption.

The prime movers (turbines for the mills and turbo-generators) required most of the live (high pressure) steam, with a small amount being required by the steam jet ejectors (for the vacuum units) and other miscellaneous uses.

The exhaust steam from the prime movers is used for heating in the juice heaters, evaporators, vacuum pans, and the boiler feed water deaerator. A small quantity is utilized for massecuite reheating, heating process water, and other miscellaneous uses.

An ideal steam balance is one where all the steam required to operate the factory can be obtained from the bagasse available. Ideally, all the exhaust produced by the prime-movers is consumed by the boiling house so that there is no excess to be vented (thereby losing heat and good condensate for the boilers). Unfortunately, the boiler, milling and processing conditions are never constant. Thus, it is necessary to provide auxiliary fuel for the boilers, a live steam make-up to exhaust, and an exhaust vent to the atmosphere (or surface condenser) to prevent upsets in one phase from affecting all phases of the factory operations.

Examples of the steam requirements in Louisiana and Florida mills are shown in the following table:

Calculated Steam Requirements
(Lbs Steam/Ton Cane)

Live Steam	LA. 150 psi	FLA. 400 psi
Prime movers	985	565
Turbo generators	395	225
Other	60	60
TOTAL	1440	850
Exhaust		
Juice heaters	275	--
Evaporators	510	765
Vacuum pans	265	--
Other	75	75
TOTAL	1125	840
Theor. minimum boiler efficiency required:	56-72	51

In Florida, the use of high pressure steam leads to lower live steam requirements in the prime movers. Florida's exhaust steam requirements are also lower, and in good balance with live steam production, by virtue of quadruple effect evaporation combined with vapor bleeding for pans and heaters. In Louisiana, few mills generate electric power, so that live steam usage is less than shown in the table, and exhaust requirements often are limiting. The past abundance of cheap natural gas led to the installation of low pressure steam generating facilities, and triple effect evaporators. These plants are not in a strong position to deal with the energy crisis. It should be mentioned here that the LSU College of Engineering, through the Audubon Sugar Institute, has initiated field work and research to aid the industry in these matters.

Reducing prime mover steam requirements: The quantity of steam required by a turbine to perform a given quantity of work is:

1. Proportional to the potential heat or enthalpy drop in the steam. The potential (ideal) heat drop increases with steam pressure and steam superheat, and decreases with increasing exhaust pressure.

2. Dependent on the thermodynamic efficiency of the turbine. Efficiency is a function of the turbine design and is primarily dependent on the wheel diameter, wheel speed, and the number of turbine stages.

For example, a turbine with a thermodynamic efficiency of 50% exhausting at 15 psig requires the following quantities of steam per horsepower-hour:

Steam conditions	Lb steam/h.p.-hr
50 psig, 25° FSH*	83.0
100 psig, 10° FSH*	53.0
150 psig, 0° FSH	39.4
250 psig, 100° FSH	28.4
400 psig, 150° FSH	22.6
550 psig, 200° FSH	19.8
700 psig, 250° FSH	17.7

*Obtained by free expansion of 150 psig, saturated steam.

Thus, higher steam pressures are critical to keeping live steam requirements down.

In practice, it is the steam condition at the turbine ring (steam available at the turbine blade) that controls the turbine's steam consumption. Thus, for minimum steam consumption, the turbine's hand valves should be controlled so that the ring pressure is only slightly less than the live steam header pressure (if the ring pressure reaches the header pressure, the turbine may stall).

Reducing boiling house exhaust steam requirements: The steam required for the boiling house can be reduced by the following methods:

1. Increase the number of evaporator effects.
2. Bleed vapor from the evaporator effects to operate heaters and/or the vacuum pans.
3. Recompress evaporator vapors to exhaust pressure for re-use. This can be accomplished by a thermo-compressor (aspirator) or a turbo-compressor.

The benefits of 1, and 2 above can be approximated using Rillieux's principles, or can be rigorously calculated with a heat balance. Vapor recompression is particularly beneficial when excess live steam is available and where the exhaust steam supply is less than the requirements of the boiling house.

Miscellaneous measures to reduce steam requirement: There are several practices that on their own only make a small contribution to the thermal efficiency, but which, taken together, may have an important effect. These are:

1. The recovery of heat from boiler blowdown, by flashing this hot water to produce exhaust steam.
2. The flashing of hot evaporator condensates to produce additional vapor.
3. Using excess exhaust to deaerate boiler feedwater.
4. The optimum insulation of live steam, exhaust, and condensate return lines; and the insulation of the boiler feed water storage tank.
5. The proper sizing of live steam and exhaust lines to reduce power-robbing pressure drop.

Summary

To achieve energy self-sufficiency, mainland U. S. sugar mills will need to make improvements in fuel quality, in boiler plant operation, and in steam utilization. Florida mills are closer to the ideal than are the Louisiana mills, but their higher unit fuel costs may require them to make still further efficiencies. The magnitude of various types of improvements possible in boiler plant and factory are shown in the tables which follow. The base cases in these tabulations are typical Louisiana mill conditions.

Summary - Boiler Plant Improvements

Case	Boiler efficiency %	Increase in efficiency
Base case*	45.5	0
Reduce H_2O in bagasse to 50%	47.0	1.5
Lower flue gas temp. to 325 F	59.0	13.5
Reduce excess air to 40%	53.5	8.0
Flue gas to 325, Xs air to 40%	62.0	16.5
Lower ash in cane by 5%	49.5	4.0

*Flue gas 550 F, H_2O in bagasse 53%, excess air - 136%

Thus, better cleaning of the cane, reducing excess air, and recovering waste heat from the stack gases are the directions in which to move.

Summary
Mill and Boiling House Improvements

	Steam reqd. lb/ton cane
Live steam	
Base case (150 psig, 0° FSH)	1438
Low ring pressure (50 psig, 25° FSH)	1934
Raise steam press to 250 psig	1053
700 psig	679
Exhaust steam	
Base case (triple effects)	1125
Quadruple effects	1009
Robbed triple effect	909
Robbed quadruple effect	840

Here, higher live steam pressures coupled with evaporator configurations designed for maximum steam economy appear to be required.

To summarize, some improvements in operating practices, especially in Louisiana, can be made to bring present equipment up to maximum efficiency. However, to attain energy self-sufficiency, added investments will be necessary. These may include heat recovery equipment, higher pressure boilers, added evaporator effects, and the like. Freedom from dependency on fossil fuels is a desirable and attainable goal.

PROCESSING OF TOTAL, CLOSE-SPACED CANE

J. A. Polack and H. S. Birkett[1]
Audubon Sugar Institute
Louisiana State University
Baton Rouge, Louisiana

ABSTRACT

Limited tests were conducted in Audubon Sugar Factory during Fall, 1976, to determine the processibility of the whole cane plant (tops and leaves included). Also tested was the processibility of cane grown under special, close-spaced (12 inch) conditions. These tests were part of the Energy from Crops program sponsored by the Energy Research and Development Administration and coordinated by the Battelle Columbus Laboratories. Cane was supplied by the USDA Sugarcane Laboratory (Houma) and the Sugar Experiment Station of LSU at St. Gabriel. Very high cane yields per acre were achieved by the USDA in their close spacing experiments. These high cane yields more than offset any drop in cane quality which amounted to no more than 15-20% in sugar yield per ton of cane. Thus, sucrose yields per acre can apparently be substantially increased by close spacing. The same is true of total fermentables, should one be growing sugar cane for alcohol production. In general, the effect of including tops and leaves was proportional to their quantity and quality. Compared to clean stalks, total cane produced more bagasse and less juice with some drop in mixed juice purity, and, of course, a loss in predicted yield. The tops and leaves contribute mainly fiber. There seems to be no incentive for including this nonproductive fraction in the mill feed. If one wishes to recover tops and leaves for maximizing fiber production, it may be best to handle them separately.

INTRODUCTION

The work described herein was part of the Energy from Crops program sponsored by the U. S. Energy Research and Development Administration. Also participating was the Battelle Columbus Laboratories who are serving as project managers for ERDA's Energy from Crops research. Their interest is in maximizing biomass production, with a view toward its conversion into fuels or chemicals. In the case of sugar cane, a product of obvious interest is ethyl alcohol. Any bagasse (fiber) produced in excess of factory energy requirements could also be available for chemicals production.

In addition to producing chemicals, improved sucrose yields could be obtained by close-spacing. Accordingly, processing of total, close-spaced cane is of interest to sugar processors. This paper presents data on processing of such cane for sugar production.

Covered in this report are factory and pilot mill results on total cane from both one foot and regular six foot spacings. Also included are results on separate processing of clean stalks as well as tops and leaves.

Cane processed in this program was supplied by the Sugarcane Laboratory of the USDA in Houma and by LSU's Sugar Experiment Station at St. Gabriel, Louisiana.

RESEARCH PROGRAM

Two sets of runs were made: the first set on cane supplied by the USDA in Houma (between November 30 and December 2, 1976); and the second using cane supplied by the LSU Sugar Station (December 13 through 16, 1976).

The USDA cane (CP 65-357) consisted of close-spaced cane (1 foot spacings) harvested on November 29; and regular 6-foot spaced cane, harvested on November 30. It should be noted here that South Louisiana experienced a fateful hard freeze on the morning of November 30. The close-spaced cane was thus cut before the freeze, and the regular spaced cane was cut afterwards. Temperatures were low throughout the period, and since all cane was processed within two days of harvesting, there was no evidence of any deterioration. On the other hand, the cane harvested on November 29 was actually processed in the mill on the morning of the hard freeze. As a result, the cane as processed was frozen, and icy conditions resulted in much slipping on the conveyor belt leading to the mill and crusher. For this reason, very low mill feeding rates were experienced during this operation.

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[1] Presently employed with F. C. Schaffer & Associates, Baton Rouge, La.

In addition to the two runs in the Audubon Sugar Factory, cane from the 12-inch spacing was processed in the small Farrel Mill (100 lb samples, each test). In these tests, the cane was separated into clean stalks and trash, or tops and leaves. Three runs were made, one on trash, one on clean stalks, and one on total cane.

The cane supplied by the Sugar Station at LSU (also variety CP 65-357) was all planted on conventional row spacings. Unfortunately, it was harvested two weeks after the hard freeze of November 30. It was considerably deteriorated. Nonetheless, two samples of total cane were processed in Audubon Sugar Factory, as were two samples of conventional burned cane. In addition, a sample mill run (100 lb charge) was made on each of the total cane samples.

In working up the factory juices, difficulty was encountered in graining the deteriorated syrups, and no raw sugar was produced. Also, the juice from the sample mill unfortunately was not analyzed.

In summary, three types of comparisons were made in this series of experiments:

1. 12-inch spacing versus 6-foot conventional spacing on total cane.
2. Total cane versus clean stalks versus tops and leaves.
3. Total green cane versus conventionally burned cane.

The data obtained included mill balances, juice and bagasse yields, juice and bagasse quality, and processibility through, where possible, to sugar production. Sugar yields were calculated assuming 96% boiling house efficiency (BHE) throretical recovery by the Winter-Carp formula. Complete data on all the runs are presented in the Appendix Tables 1 and 2. Details of procedure are presented in the Appendix also.

RESULTS

Processibility

Cane milling: The conveyor belts from feeder table to the mill are on a rather steep angle at Audubon Sugar Factory (26°). Difficulty was encountered on the morning of November 30 in processing whole cane which was partially frozen. The icy, leafy material tended to slide on the conveyor with the result that milling rates were substantially lower than normal. However, subsequent milling of unfrozen total cane proceeded without difficulty and full mill capacity was realized.

Clarification: Slow clarification was experienced in the first processing of total cane (November 30) which included the tops and leaves. As shown in Table 1, the starch content of the mixed and clarified juices was reasonably high. On the subsequent factory run (December 2) on total, regular spaced cane, the double clarification method of Ashby Smith (1) was employed. In this method, the limed juice is first heated to about 135 F, clarified by settling, and the resulting clarified juice is then reheated to the boiling point for a second clarification step. This procedure resulted in the reduction of the starch content as shown in the data in Table 1. This double clarification procedure was not used in the treatment of the LSU cane in which gum was more troublesome than starch. Of course, double clarification takes more time, and this was a serious constraint, especially in our later operations.

Table 1. Processing of whole cane - Fall 1976.

Test series	Houma cane (CP 65-357)		Close-spaced		
Description	Close-spaced whole cane	Regular-spaced whole cane	Tops & leaves(5)	Stalks(5)	Total cane
Tested in	Audubon Sugar Factory		Sample mill		
Date cut	11/29/76	11/30/76	11/29/76		
Date milled	11/30/76	12/2/76	12/1/76		
Temp. °F (Hi/lo)	48/21	53/43	60/24		
% cane: Trash	20.0	10.0	--	--	17.1
Imbibition	19.29	19.44	23.29	20.08	20.45
Mixed juice	78.63	78.23	20.09	86.95	73.62
Bagasse	40.66	41.21	103.21	33.13	46.83
Pol	9.59	10.70	1.45	12.95	11.59
Brix	12.82	13.86	4.67	14.90	13.91
Fiber	16.97	18.50	49.08	12.29	19.65
Mixed juice: Brix	13.59	14.98	9.66	15.04	16.39
Pol	10.22	11.67	3.00	13.07	13.66
Purity	75.20	77.90	31.06	86.90	83.34
R.S. ratio	4.11	5.06		1.76	2.41
Starch (PPM on bx)	737	569	588	357	414
Gum (PPM on bx)	7001	11966	15344	4041	5523
Dextran (PPM on bx)	--	1134	--	--	--

Table 1. (Continued)

Test series Description	Houma cane (CP 65-357)		Close-spaced		
	Close-spaced whole cane	Regular-spaced whole cane	Tops & leaves(5)	Stalks(5)	Total cane
Clarif.juice: Purity	81.11	81.48(1)			
Starch (PPM on bx)	194	84(1)			
Gum (PPM on bx)	2535	3628(1)			
Dextran (PPM on bx)	--	687			
Bagasse: Moisture	53.0	49.9	49.80	57.40	54.10
Pol	3.82	3.82	0.82	4.78	3.28
Brix	5.26	5.20	2.64	5.50	3.94
Fiber	41.74	44.90	47.56	37.10	41.96
Pol extraction, %	83.80	85.29	41.59	87.77	86.75
Milling rate, tons/hour	3.34(2)	8.48(2)			
Calc. yield(4), lbs 96° sugar/ton					
Gross	139.5(3)	161.87	1.35	213.58	185.05
Net	174.4	179.85	--	--	212.95

(1) Juice subjected to double clarification (cold & hot) method of B. A. Smith. Data after 2nd step.
(2) Cane slipped on carrier. Partly frozen, partly leafy.
(3) Sugar had greenish cast.
(4) Assume actual extraction; 96 BHE; theoretical extraction = 1.4 - 40/P.
(5) Total cane composed of 17.1% tops and leaves, 82.9% stalks.

Sugar boiling: The total cane from Houma produced raw sugar which seemed to have a greenish cast. Otherwise, it presented no difficulty in making A sugar.

On the other hand, the LSU cane, processed two weeks after the freeze, produced a gummy juice. Inspection of the mixed juice quality, Table 2, shows the high contents of gum and reducing sugars. We had no success in graining this material due to the gummy nature of the syrup. After failing in our attempts to grain this material, we abandoned subsequent efforts to make sugar from it.

Table 2. Processing of whole cane - Fall 1976.

Test series Description	LSU cane (CP 65-357)			
	Whole cane No. 1	Burned cane No. 1	Whole cane No. 2	Burned cane No. 2
Tested in	Audubon Sugar Factory			
Date cut	12/13/76	12/14/76	12/15/76	12/15/76
Date milled	12/13/76	12/14/76	12/15/76	12/16/76
Temp. °F (Hi/lo)	53/43	51/40	61/49	67/38
% cane: Trash	21.0	10.0	24.0	8.0
Imbibition	19.74	20.04	23.26	21.35
Mixed juice	79.76	81.83	85.06	86.05
Bagasse	39.78	38.21	38.21	35.30
Pol	7.54	8.91	7.14	8.0
Brix	10.84	11.87	10.13	11.50
Fiber	18.09	15.53	17.47	16.69
Mixed juice: Brix	11.70	12.05	9.90	11.80
Pol	8.20	9.10	7.05	8.56
Purity	70.09	75.52	71.21	72.54
R.S. ratio	11.09	9.56	13.48	10.75
Starch (PPM on bx)	392	238	408	583
Gum (PPM on bx)	20408	24939	13605	12138
Dextran (PPM on bx)	327	871	389	890
Clarified juice Purity	72.90	76.09	70.16	73.95
Starch (PPM on bx)	52	49	58	460
Gum (PPM on bx)	5771	6321	10557	7524
Dextran (PPM on bx)	87	408	144	293
Bagasse: Moisture	50.80	54.10	49.80	48.90
Pol	2.46	3.82	3.00	2.46
Brix	3.74	5.27	4.48	3.81
Fiber	45.46	40.63	45.72	47.29
Pol extraction, %	87.01	83.61	83.95	89.46
Milling rate, tons/hour	15.9	3.8 (2)	8.37	14.74
Calc. yield(1), lbs 96° sugar/ton				
Gross	108.8	129.6	100.5	125.02
Net	137.7	144.0	132.3	135.89

(Continued)

Table 2. (Continued)

---

(1) No sugar made in these tests due to poor quality of syrup. Gummy material in pan. Assumed: actual extraction; 96 B.H.E.; Theoretical Extraction by Winter-Carp.
(2) Trouble feeding 1st set of knives.

Factory Results--Houma Cane (Total Cane)

Data from the comparison between 12-inch and 6-foot row spacing are given in detail in Table 1, attached, and are summarized below:

Table A

Factory results - total cane
(Houma cane - 11/30-12/2/76)

	Close spaced	Regular spaced
Trash, % cane	20	10
Pol, % cane	9.59	10.70
Mixed juice, % cane	78.63	78.23
Mixed juice, purity	75.20	77.90
Mixed juice, gum, ppm on brix	7001	11966
Pol extraction, %	83.8	85.3
Calc. yield, lb/ton, gross	139.5	161.9
Net	174.4	179.9

Inspection of Table A yields the following observations:

The close-spaced cane as tested in Audubon Sugar Factory had slightly higher trash than the regular spaced cane. The pol % cane was slightly lower (9.59 versus 10.7%). This difference may not be significant. Caution is recommended in interpreting the results of single tests. The production of mixed juice was about the same for both samples and the mixed juice purity was only slightly less for the close-spaced cane. Gum content of the juice of the regular spaced cane was high, possibly reflecting the fact that it was harvested after the freeze. Extractions were good on both samples, and calculated yield, while lower for the close-spaced cane on a gross ton basis, was only slightly lower than the regular-spaced cane on a net ton basis (174 versus 179.9 lb per ton).

Again, these differences may or may not be significant. Most likely, the results agree within experimental error.

The yields of sugar per acre are shown in Table B.

Table B

Yields per acre

	Close spaced	Regular spaced
Cane, gross tons/acre(2)	145	62
Cane, net tons/acre(2)	87	51
Sugar yield, tons/acre	7.57	4.61

---

(2) Data supplied by Dr. J. E. Irvine, USDA, Sugarcane Laboratory, Houma, La.

A substantially higher yield, 7.57 tons per acre was obtained from close-spacing (4.61 tons per acre for regular spacing). Each of these figures is a high number, as a result of the high cane yields per acre experienced under the experimental conditions of the Houma Laboratory. But the obvious advantage for close spacing is most interesting--both from the point of view of the sugar processor or the possible alcohol producer.

Clearly, the outstanding field tonnage, achieved by close-spacing, carries through and shows itself as more sugar produced per acre. There may be some loss in cane quality due to close-spacing, but the field advantage more than offsets it.

Sample Mill Results--Houma Cane

The detailed results of the sample mill tests on tops and leaves, stalks, and total cane, are also shown in Table 1. These results are summarized below in Table C.

Table C

Total cane processing
(Houma cane - 12/1/76)

Sample Mill Results

	Tops & leaves	Clean stalks	Total cane	
			Meas.	Calc.
Percent by wgt.	17.1	82.9	100	100
Trash, % cane	100.0	0.0	17.1	17.1
Mixed juice	20.11	87.0	73.6	75.5
Bagasse	103.2	33.1	46.8	45.1
Pol	1.45	12.95	11.6	11.0
Brix	4.67	14.9	13.9	13.2
Fiber	49.1	12.29	19.7	18.6

It is obvious that the tops and leaves are very poor from the point of view of juice production and pol content--the latter only 1.45%. In fact, the juice produced was little if any more than the imbibition water added in the process. Thus, these tops and leaves contributed almost exclusively to fiber.

The clean stalks, on the other hand, were excellent, as one would expect. The yields and quality shown in the second column of Table C above ave conventional.

The results on total cane (see third column) are somewhat poorer than those on the clean stalks, as one would expect as a result of the inclusion of the tops and leaves. Most interesting is the excellent agreement between the last two columns. The last column gives the yields and quality from the total cane, calculated by simply blending the results on tops and leaves with those on the clean stalks in appropriate proportions by weight. This result may at first seem surprising, since one would assume that the inclusion of the trash would cause a reduction in yield: the additional fiber would be expected to absorb some added sucrose, thereby reducing yield. This effect may actually occur. It is simply that the amounts involved are too small to be seen by the procedures used; and many replicated runs would be required to determine if such an effect actually took place.

Sugar yields from these operations are shown below:

Table D

Sample Mill Yields, Lbs Sugar/Ton

Tops and leaves	1.35
Clean stalks	213.6
Total cane	185.1

There seems to be no virtue to including trashy tops and leaves in the mill. All that would be accomplished is that the mill through-put would be accordingly reduced. It would be better to process an equal weight of clean stalks.

If capacity were of no concern and one wished simply to maximize bagasse production, then there might be some reason to include tops and leaves in the mill feed.

Results on LSU Cane

Detailed data on the LSU cane are shown in Table 2. As has been pointed out, this cane was harvested about two weeks after the bad freeze. Warm temperatures existed after the freeze and before harvesting. Also before and during the actual harvesting, heavy rains were encountered. Although the cane was hand cut, conditions were far from ideal.

It has already been mentioned that attempts to grain sugar from this cane were unsuccessful and abandoned. Accordingly, the principal experimental results were the juice production and juice qualities. Yields (as is always the case) are calculated assuming the actual extraction, 96% BHE and theoretical recovery by the Winter-Carp formula.

Examination of the data in Table 2 reveals that the burned cane had less trash (as expected), higher juice production, and better juice parity than the total cane. As a result, slightly higher net yields were calculated for this material. Again, one should be cautious about drawing conclusions from these numbers, differences between which are probably not significant. Directionally, the results are the same as those described earlier: namely, the inclusion of trash is, as expected, deleterious.

The main thing to note in this whole series is that the cane as supplied was of generally poor quality. This is illustrated by the reducing sugars ratio, the high gums, and the high dextrans. These various impurities no doubt accounted for the difficulties experienced in attempting to grain.

The sample mill gave some bagasse and juice production data which are in fairly good agreement with those from the Audubon Sugar Factory tests. Unfortunately, the products from these runs were never analyzed. However, all of our experience would lead us to expect the same results as those obtained in the larger mill.

CONCLUSIONS

This work has shown that the very high yields of sugarcane in tons per acre, obtained through close-spacing in the fields, also lead to very high sugar yields. Only slight debits in juice production and quality were shown for the close-spaced cane--and it is not known whether these slight differences were statistically significant. Accordingly one predicts that very high sucrose yields per acre may be realized through the factory processing of the close-spaced cane.

In these tests, the overall sugar per acre was increased by about 50%. Surely, this interesting result is worthy of further study.

From this work it is also concluded that there is no benefit for the milling of tops and leaves, or for that matter their inclusion along with clean stalks of cane. Should there be a need for additional fiber, separate processing of these trashy materials might be worth investigating. They could be included with the regular stalks in the special case where there is excess mill capacity and the additional bagasse is desired. From the viewpoint of alcohol and other chemical production, close-spacing appears to be a desirable way to increase biomass production.

Further consideration will have to be given to new methods of harvesting the Louisiana crop should there be a change to 12-inch row spacing.

ACKNOWLEDGEMENTS

We acknowledge with deep thanks the invaluable contributions of Dr. Mike Giamalva and personnel of the LSU Sugar Station; and of Dr. J. E. Irvine and associates at the USDA Sugarcane Laboratory at Houma; and last, but not least, the entire staff of the Audubon Sugar Institute.

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APPENDIX

PILOT PLANT TEST PROCEDURE

Equipment (Audubon Sugar Factory)

Milling: The factory is equipped with a Squier milling tandem at 360 tons/24 hours and consisting of a two-roll crusher and three 3-roll mills.

Clarification: The pilot plant clarification equipment consists of:
- Two 100 gallon liming tanks equipped with Lightnin' portable mixers.
- Two Ross shell and tube heat exchangers having 25 sq. ft. total heating surface.
- Five 100 gallon open clarifier tanks.

Evaporation: Forced circulation evaporator having 11.75 sq. ft. heating surface.

Crystallization: Two calandria-type vacuum pans of about 10 gallons capacity. One Bird centrifugal operating at 1750 rpm.

Procedure

Each lot of cane (2 or 3 tons) was processed through the milling tandem and the pilot plant.

Each lot of cane was weighed, sampled for trash, and milled with 20 percent maceration water on cane and at a third roll speed of 30 fpm.

The extracted (mixed) juice was then transferred to the pilot plant where it was limed cold to 7.5 pH, heated to 212°F and settled in the clarifiers. In addition, phosphoric acid was usally added to the cold juice before liming, and the Separan AP-30, a carboxy-amide type polyelectrolite, which is manufactured by the DOW Chemical Company, was added to the hot juice as it eneterd the clarifiers. The optimum juice treating conditions as pH and phosphoric acid and coagulent dosage were determined in the laboratory prior to the pilot plant run.

The use of Separan AP-30 and phosphoric acid is not uncommon in raw sugar manufacturing where clarification problems are encountered.

Upon settling, the clarified juice was then transferred to the evaporator feed tank and evaporated to syrup.

In the crystallization stage, the syrup was initially boiled to make grain (grain strike). The pan was seeded with a slurry of confectioners sugar in isopropanol. A footing of grain was left in the pan for a sugar strike which was completed with syrup. The resultant massecuite was transferred to the centrifugal. As a massecuite charge was drying in the centrifugal, a small amount of wash water was added--as would be done on a commercial scale operation. The products from the centrifugal were sugar and molasses.

SAMPLE MILL EQUIPMENT AND TEST PROCEDURE

Equipment

Three-roll sample mill: The three-roll sample mill which was used in studies was designed by the staff of the Chemical Engineering Department and the Audubon Sugar Factory, and constructed and presented to the Audubon Sugar Factory by the Farrel-Birmingham Company of Ansonia, Connecticut. The mill weighs 14,125 pounds and measures approximately six by eight feet. All metal sections of the mill are annealed and stress-relieved. The mill is powered by a 220-440 volt, 15 HP motor with a four to one speed variation which gives an effective mill speed of about eight to forty feet per minute. A 4 1/2 inch floating shaft connects the reducer to the actual mill. This shaft drives the cane grinding unit which consists of three twelve inch by twelve inch rolls. The rolls are grooved to three-eighth inch with a pitch angle of 50°.

The mill is equipped with a Blackhowk hydraulic system which consists of a pump and oil reservoir mounted on the machine base. This system is capable of delivering a maximum hydraulic pressure of 2000 psig which is equivalent to forty one tons per foot of top roll. The hydraulic system includes two Edwards accumulators with piping, gauges, and roll float indicators. The mill employs a central force-feed lubrication system which distributes oil to six points on the mill.

The cane feed chute is twelve inches wide by eight inches deep, and is mounted at an angle to facilitate feeding. The bagasse chute, which is wider than the rolls, is inclined at an angle to provide gravity discharge of the bagasse.

Galvanized iron trays approximately five feet long by twelve inches wide by eight inches deep are provided to facilitate feeding cane or bagasse to the mill. The trays are so constructed that the cane or bagasse can be placed in the trays and the trays inserted in the cane feed chute. When the trays are tilted the feed enters the mill by gravity.

Procedure

A 100 lb sample of cane is weighed and fed manually through the feed chute into the mill. Maceration water is delivered by gravity from a cylindrical drum, equipped with a graduated sight glass. The water rate is controlled by hand to give the desired water addition--usually 20% by weight distributed equally over the first 2 passes through the mill. The water is fed to the bagasse as it emerges from the rolls.

Standard procedure was to use 3 passes through the mills. The bagasse from the first pass was collected and fed through the mill for the second pass. Similarly, the bagasse from the second pass was collected and given a third pass through the mill. No water was added to the final bagasse. Juice from all passes is accumulated, mixed, weighed, and sampled for analysis. The final bagasse was also weighed and sampled for analysis.

COOLING SPRAY POND: PERFORMANCE EVALUATION[1]

A. Tellechea
Gulf + Western Technology Corp.
Coconut Grove Station
Miami, Florida

ABSTRACT

It has been observed that, during periods of adverse meterological conditions, the sugar mill does not reach its design capacity, due to elevated cooling water temperatures. The spray pond system performance has been evaluated using data and thermal performance prediction techniques similar to those used in the nuclear industry. In the evaluation, modifications in design and operation were considered which would lower cooling water temperature, to allow the plant operation to achieve a higher capacity. The basic modifications evaluated were increased spray flow rate with the existing piping design and no additional nozzles, and increased flow rate combined with raising the nozzle elevation above the water surface. The results of the evaluation show the percent of design capacity for each change in design or operation, and for various wet bulb temperatures. These results are given primarily to show the relative increase in production that should be realized for the various methods of operation, and are not absolute values that can be used to predict plant output. In view of the flexibility in the plant design to increase the flow to the spray pond without further capital investment, the recommended procedure is to maximize spray flow rate. Raising the nozzles did not significantly increase the thermal performance, considering the expense and inconvenience of the change. With the flow rate maximized, there will still be some days when full plant capacity will not be realized, most likely those days whose average wet bulb temperature exceeds 75 F. The present situation at the sugar mill is a temporary one, since an expansion is planned next year. It is recommended that any design changes to further improve performance be coupled with the expansion. There are design changes that can be made during that expansion which will allow full plant capacity, even for days having an 80 F average wet bulb temperature.

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[1] Only the Abstract of the paper was available for the Proceedings.

OLD AND NEW TECHNIQUES IN PROCESSING FREEZE-DAMAGED CANE[1]

Carlos R. Toca
Carlos R. Toca, Inc.
New Iberia, Louisiana

ABSTRACT

Experiences which occurred in processing freeze-damaged cane in Louisiana and Florida during the past crop will be discussed, including such factors as cane conditioning, recommendations on liming and bacteriological treatment, chemicals to be used and the boiling system.

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[1] Only the Abstract of the paper was available for the Proceedings.

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PRESIDENT'S MESSAGE: LOUISIANA DIVISION

R. D. Breaux
U.S. Sugar Cane Field Laboratory, USDA, Science and Education Administration

Last year, the Louisiana sugar industry, for the 183rd time, produced, harvested and processed another sugar crop. It was what seems to have become our "normal" growing season: a wet fall planting; a late cool spring; a dry early summer, with a hurricane at the end; and a cold, wet and miserable harvest. Still, Louisiana produced 668,000 tons (601,200 tonnes) of sugar, raw value, in 1977, the highest level in a decade. We averaged almost 24 net tons of cane per acre and our mills extracted 185 pounds of sugar per net ton of cane.

In spite of this performance, the lifetime prophets of doom for the Louisiana sugar industry, or the entire domestic sugar industry for that matter, believe that their predictions are finally being realized. They say that good sugar cane growers and processors were forced to go out of business, or elected to do so, and point to the increasing amount of sugar cane land now growing soybeans or corn. The fact that we lost two sugar mills after the 1976 crop and five more mills this year is used as further evidence of decline.

The Louisiana sugar industry has seen better days. What we must not forget, lest we succumb to depression, is that the sugar industry has faced, and solved, most of these same problems time and time again. Louisiana growers and processors have historically used three main avenues to solve their problems. These avenues are still wide open today, and as useful as ever.

The first avenue to survival has been a close-knit organization of growers and processors which speaks and acts effectively in the best interests of all segments of the sugar industry. Does not the relentless, tenacious leadership of the American Sugar Cane League in securing a US $0.135 support price for the 1977 crop prove that this means of solving a problem is still a viable alternative? Does it not also suggest that new sugar legislation, offering a brighter, more stable outlook for the industry, is also attainable?

A second historical means of problem solving has been to foster, support and encourage research, and to use its products. A recent example is the rapid expansion and general acceptance of early maturing, high-sucrose varieties from the cooperative breeding program. The industry can recover 190 to 200 pounds of sugar per net ton of cane (tropical sugar recoveries in a seven to nine-month growing season) in future harvests, barring a severe early freeze. Last year, the sugar cane borer did not develop normally in Louisiana. Growers clearly demonstrated, once again, the confidence they place in experiment station recommendations by completely avoiding unnecessary insecticide applications. If time permitted, I could cite many other examples of the timely application of new technology by our growers.

The third and primary reason that the Louisiana sugar industry will solve its problems is the character of the Louisiana sugar cane growers, particularly those with family type farms or operations. As a whole, they are very adventuresome, but, at the same time, they are experienced managers of a low-cost, low-profit business and they have a very stubborn survival instinct. I wish that anyone who doubts their enthusiasm had seen them gobble up massive amounts of expensive field equipment at auctions in and around Houma last January. It seemed obvious to me, that the misfortunes of those who had to cease operations will provide additional opportunity for those who remain.

I am confident that the Louisiana sugar cane industry will continue to mystify all foreign and some domestic experts, who just do not understand it. Louisiana's sugar industry will exist for at least another 183 years, if we, its technologists, continue to support it. We must persist in the exploration of new sugar cane germplasm and the incorporation of genes from wild relatives and related genera. It will take decades, but these new genes may be desperately needed some day.,

We can adjust our row width and plant geometry in Louisiana and have a potential of 80 tons (72 tonnes) of cane per acre with our present soil, climate and varieties. We must develop a profitable technology to harvest these heavy tonnages, even though radical changes will be necessary.

It is now possible to convert cellulose (bagasse) to glucose using sulfuric acid, which is extremely cheap. It is being considered for corn stover, usually left in the field, why not for surplus bagasse, which is already hauled to the mill?

We have been leaving highly merchantable cane in the field in Louisiana because it is too wet or boggy. Cannot our traction problems be solved with weight-transfer wagons, or in some other way?

The message that I hope to convey from the Louisiana Division is that the sugar cane grower deserves the same daring, courage, enthusiasm and confidence from his support people and technologists that he exhibits when he plants a sugar cane crop in these uncertain times. He is financially strapped, so he will insist that any proposed new technology be thoroughly tested in the field or factory and its profitability be clearly demonstrated. However, he does not expect us to hesitate to evaluate technologies that will obviously take a long time to bring to fruition, or will require radical change. After all, this is how he expects his children to survive in this business.

PRESIDENT'S MESSAGE: FLORIDA DIVISION

Blas M. Rodriguez
Assistant to Vice President Sugar Houses, U.S. Sugar Corp.

Florida's 1977-1978 sugar cane harvest season came to an end on April 7, 1978, when "Glades Sugar House" completed its grinding operations. Over 160 days had passed since Osceola Farms Co. officially started the crop, on October 26, 1977.

As we compare the results of our recent crop with those of the past, we note that the average number of crop days for the seven sugar mills in the state during the 1977-1978 campaign was only 126; a rather short season by Florida standards, and a consequence of the record-breaking cold temperatures experienced throughout the Florida cane-growing areas in January and February, 1977. The nearly 300,000 acres harvested during the 1977-1978 season produced 9,029,000 tons (8,126,000 tonnes) of cane, almost a 10 percent decrease from the preceding year and 877,142 (789,428 tonnes) of 96° Pol. sugar, or 4.0 percent less than the sugar produced in the 1976-1977 crop year. These production figures fall within the last five years' average, in spite of the adverse weather conditions.

With sugar inventories mounting all over the world, since production is keeping a substantial margin over consumption, it would be illogical to expect a rise in the price of sugar on the world markets in the near future.

Different measures recently taken by President Jimmy Carter and the efforts of some members of the legislative branch of the United States government appear to have brought some relief to the mainland sugar industry. However, we must remember that this is only a temporary measure, and a more permanent solution must be enacted by our government's leaders. We have to realize that, ultimately, it is in our own best interests not to depend on the federal government for our existence as a profitable industry.

We owe it to ourselves, as modern sugar technologists, to take a long, hard look at some of our old, established practices, both in the area of agriculture and in processing, and make changes where warranted.

When we Floridians look to the past, we must realize how much we are indebted to research in the development of canes which are resistant to diseases and also suitable to our soil and weather conditions. These same varieties produce the tonnage and sucrose content that has made the South Florida sugar industry a prosperous one. We must continue to use our existing research facilities to the fullest to develop even better cane varieties, as well as advanced agricultural methods and techniques. This will enable us to make the most of the acreage available, in order to produce sugar on a basis that is competitive, not only with other natural or artificial sweeteners, but also with other sugar-producing areas throughout the world.

In the area of sugar manufacturing, Florida has gone through a major expansion during the last few years. Large capital expenditures, made possible by the high sugar prices that peaked in 1974, have brought the average capacity of the seven mills in operation to well over 10,000 tons of cane per grinding day, a figure unmatched anywhere in the world. Now it is up to us to take the steps to use this modern equipment, coupled with today's technology, to offset the rising cost of labor and materials. Consequently, we must not only continue our efforts to keep production costs competitive, but also increase our endeavor to develop by-products from sugar cane and find new uses for the existing ones.

Considering by-products, I feel it imperative to mention what we had the opportunity to see in Brazil while attending the XVI Congress of the International Society of Sugar Cane Technologists. With the government's assistance, the Brazilian sugar industry has engaged in a dynamic alcohol-producing program. This program provides a buffering action against the sweeping fluctuation of the price of sugar on the world market, and is securing Brazil's position, both present and future, as the leading sugar-producing country in the world.

The members of the sugar industry in Florida, processors as well as producers, have continued to work closely with federal, state and local agencies in an effort to comply with the 1972 Water Quality Act and to determine the facts relating to water quality in the Everglades agricultural areas. Through the Florida Sugar Cane League, the industry is financially supporting studies of cane, vegetable and cattle operations, and will soon release its results. Proper management of area water resources is, of course, of vital importance to the survival of the industry.

Extensive research and continued monitoring of air quality, together with the millions of dollars spent on equipment, have resulted in our being considered the leader in the arrest of particulate emissions from bagasse-burning boilers.

We have not escaped the eye of Occupational Safety and Health Administration, either. For the first time, during this past crop, all of us were inspected and, as a whole, generally fared well. When we stop and think for a moment of the amount of concern and monies that have been spent, we realize how much progress we have made toward creating a safer environment in which to better live and work.

As much as we have accomplished thus far in these areas, however, we must not become complacent. Now, more than ever in the history of our business, we are in the public spotlight. CBS's "Sixty Minutes" and Senator George McGovern, in his "Dietary Goals for Americans," have given one-sided coverage to unscientific claims against the use of sugar, while the Federal Trade Commission has proposed a ban on the advertisement of products with a high sugar content on programs aimed at children under 12. This situation adds a new dimension to our jobs; as technicians by education and experience, we must prepare ourselves to act also as public relations men, to preserve our own interests.

In conclusion, the solving of problems faced by the sugar industry today must be undertaken with the same sense of tradition, dedication and perseverence exhibited through the years by the Louisianans, as well as by the men whose exemplary work is within our generation, the ones who have made our relatively young industry in Florida possible.

SUGAR: PROSPECTS AND PROBLEMS*

Ray Fitzgerald
Agricultural Stabilization and Conservation Service

Speaking before you today would be easy for me if I could tell you that the Administration was prepared to propose a 5-cent hike in sugar supports. It would be more pleasant if I could promise substantially higher fees on imported raw sugar. Right now I can't offer you either.

The Carter Administration is committed to the survival of the domestic sugar industry. Sometime today President Carter will be meeting with several Senators from sugar producing areas -- at their request -- to discuss proposed changes in the current sugar program. In addition, we asked for public comment last week on a proposal to increase import fees for sugar and adjust these fees quarterly.

However, I must emphasize that our overriding domestic focus today is the destructive double-digit inflation we're facing in food prices. As President Carter said recently in Chicago, "The worst economic problem. the worst domestic problem that we have now is inflation."

Significantly increasing supports for sugar producers at this time would add another coil to the inflationary spiral of food prices. We believe there are better ways to gradually reduce the squeeze our producers are caught in.

Today, American sugar producers meet about 55 percent of the demand for refined sugar in this country. Imports fill out the remaining 45 percent of our needs.

In the 1978/79 marketing year, we anticipate that domestic cane producers will grow enough cane to just about equal their production last year -- 2.7 million tons. We expect 3.1 million short tons from beets and imports of 3.4 to 3.8 million tons this year.

I think it's important to recognize that the financial plight of our cane producers is not caused by imports per se. We need imports to meet the needs of consumers who last year ate a little more than 95 pounds of sugar each.

No, it's not imports. It's the price of imports. The price is too low compared with unavoidable costs of production our farmers face.

The world sugar market is subject to one of the most vicious commodity cycles of any major agricultural product. As cane sugar processors, you're caught today at the bottom of the 10-year boom-and-bust cycle which has characterized the sugar market for the last century -- despite quotas, import fees and other devices to regular supply and price.

Record sugar production throughout the world last year increased carryover stocks and sent world prices plummeting. Raw sugar imports have been bringing between 7 and 9 cents per pound since the first of this year. That is less than the cost of production, even in the country of origin.

USDA projections indicate that it will cost the average U. S. grower 15.2 cents to produce a pound of 1978-crop raw sugar. With world prices on the downswing, it's become impossible for our producers to compete freely with imports.

We recognize the gravity of this situation. Producers are losing markets and you're losing business as refiners turn to cut rate imports. Last year the switch from domestic to foreign raw sugar accounted for a new record in tonnage imported--6.1 million tons.

I know it isn't that our farmers are inefficient. They've got problems beyond their control. Increasing environmental regulations and special minimum wage standards up their costs. Not to mention the general cost increases in energy-related products that have set most of our farmers back.

Weighing both the farmer and processor's interest against the consumer's interest puts the Department of Agriculture on a tight rope. It's a tough balancing act.

In November 1974, the average price of raw sugar hit 64 cents a pound. Although it dropped back to about 10-1/2 cents last summer, consumers haven't forgotten those high prices. And their voices in protest against higher sugar supports and higher market prices have to be considered, especially during a time of general inflation.

As a result of the high prices and consumer pressure, the Sugar Act of 1948 was allowed to expire on December 31, 1974. When prices fell below the cost of production last summer, USDA introduced an interim price support payment program. The interim program was superseded by the 1977 Food and Ag. Act. That Act created a new price support loan or purchase program which requires support for sugar from 52.5 to 65 percent of parity--or at least 13.5 cents per pound. The current support level for 1978-crop raw cane sugar is 14.65 cents per pound.

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*This was an invited paper.

Today the national average cost of production for our sugar producers is just about double the world market price for raw sugar. As I said earlier, the price of imports is our biggest problem in the sugar industry.

Therefore we see the new International Sugar Agreement as the most promising prospect on the horizon. We're looking to this agreement as the cornerstone of the Administration's sugar policy.

Once the agreement is in effect, world sugar supplies available to the international market will draw closer to demand which should strenghen prices. Prices should also be more stable--eventually in the range of 11 to 21 cents a pound. That's a welcome change from the roller coaster ride sugar prices have experienced recently. Stronger prices abroad mean a stronger industry here in the U. S. The agreement will thus benefit producers, processors and consumers alike with more reliable supplies and prices.

Let me briefly review some of the major provisions of the pact with you. These provisions were accepted on October 7, 1977, and the five-year agreement went into effect on a provisional basis on January 1, 1978.

The first key to the ISA is the regulation of exports through Basic Export Tonnages established for major shippers. The agreement provides special considerations for trade with the EC and Socialist countries. Plus, there is some leeway for developing nations.

Each year the ISA will estimate import requirements and pro-rate the tonnages among exporters based on their Basic Export Tonnages. Exporters who cannot fulfill their share may turn back part of their quotas to the ISA. Essentially these provisions divvy up the export market based on past production.

The second key is regulation of price through a system of reserve stocks which will be accumulated when prices are below 14 cents and released when prices rise beyond 19 cents per pound. The goal is a reserve supply of 2.5 million tons held by exporters, financed with no-interest loans from export or import fees imposed on all sugar traded on the world free market. Currently ISA uses the London daily price to determine when quotas are to be imposed or stocks released. ISA members also agree to limit imports from countries which haven't signed the agreement.

Let's be honest. Commodity agreements haven't got the best track record. Yet our trade experts believe that this one has a better chance than any we've seen of really managing supplies and prices. To really insure a stable and acceptable price for the domestic market, we've got to manage the world market as well.

To make the agreement work--for us and others--U. S. participation is vital. We're only provisional members until the Senate ratifies the agreement. Just last week the Executive Board of the ISA recommended extending the deadline for ratification from July 1 to December 31--primarily because the U. S. probably will not meet the earlier deadline. In truth, the viability of that agreement and stability of the world sugar market hinges on our ratification of the ISA.

Bringing foreign prices in line with our own can only serve to benefit sugar producers throughout the world. It's to our advantage to ratify the ISA as soon as possible.

The Administration is also proposing legislation which would bring the sugar program in line with programs for other major commodities and offer some protection to our domestic industry until the ISA is fully effective. First, the legislation authorizes our participation in the ISA.

Second, it sets up a program of target prices for sugar. Initially the target price would be the 14.65 cent support level authorized for the 1978 crop. However, the target would be adjusted upward annually from a base of 14.05 cents per pound, based on production costs, excluding land values.

We recommend establishing a domestic market price objective of not less than 13.5 cents per pound. In addition, we propose temporary import fees to provide border protection until world market prices hit ISA goals. Also, we are asking for standby authority to impose global import quotas temporarily, if necessary to meet the domestic market price objective.

Finally, we are suggesting a waiver of part of the interest and/or the principal, if necessary, to encourage repayment of outstanding 1977 and 1978 sugar loans.

We believe these measures will prove anti-inflationary. We'll have reasonably stable prices and than a slow escalation as world prices rise through the ISA. Consumers will pay less for sugar, and at the same time the Treasury drain from support payments will be more than offset by the revenues from the import fees and duties collected on imports until world prices reach domestic levels.

This program would be low in cost and would reinforce the goals of the ISA, consistent with our overall policy of gradually reducing trade restrictions.

What we want to avoid is any program which would significantly increase domestic prices. We don't want a program which would stimulate production and thus undercut the objectives of the ISA. At the present time there are a number of bills before the Congress which would do just that. And at a very heavy cost.

Several bills would mandate significantly higher support prices, beginning at 17 cents adjusted quarterly. Since the average cost of production is now 15.2 cents, this means we'd be supporting all producers at the production costs for the least efficient growers--12 percent higher than the average.

Such a proposal is flatly inflationary, and the President has indicated his unwillingness to sign, and indeed his intention to veto, inflationary farm legislation. In April, speaking to the American Society of Newspaper Editors, President Carter said, "I will veto any farm legislation, beyond what I have already recommended, that would lead to higher food costs or budget expenditures."

Not only would the costs of these programs strain the budgets of consumers, the artificially high prices would attract additional domestic production of sugar and corn sweetners according to USDA analyses.

Of greatest concern to you as processors is the increased competition sugar would face from high fructose corn syrup if the price of sugar inflates as rapidly as proposed by some legislation. Our estimates are that HFCS production might double over the next three years--to the detriment of the sugar industry.

As I see it, competition from HFCS is as big a problem as, if not bigger than, low prices for domestic sugar. Perhaps that explains why some of the strongest backers for higher sugar supports are lobbyists representing corn producers.

Under present conditions, HFCS shipments are expected to rise 20 to 30 percent in 1978 over shipments in 1977. A record grind of 400 million bushels is anticipated for this year with the grind exceeding 500 million bushels by the early 1980's. Most of the increase in the grind is going into high fructose corn syrup.

No one questions that these are very difficult times for sugar producers and processors. But boosting domestic prices further out of proportion with world prices and the prices of other sweetners is not the answer.

As we see it, only a gradual escalation of domestic sugar prices--in concert with the International Sugar Agreement--can bring about the lasting stability our producers, our processors, our consumers and our foreign neighbors need.

SUGARCANE WASTE PRODUCTS AND CHICKEN MANURE AS SUPPLEMENTAL FEED FOR CRAWFISH[1]

James W. Avault, Jr., Mike J. Giamalva and Ricardo Hernandez
Louisiana Agricultural Experiment station
Baton Rouge, Louisiana

ABSTRACT

The objective of these studies was to determine if sugarcane bagasse, sugarcane filter cake, chicken manure, and various combinations are suitable as supplemental food and fertilizer for red swamp crawfish, Procambarus clarkii (Girard). The first study consisted of four treatments in replicated ponds with the following results: 1. Sugarcane bagasse was applied twice at a rate of 2000 kg/ha each time, yielding an average of 280 kg/ha of crawfish. 2. Chicken manure was applied at a rate of 20 kg/ha/day yielding an average of 438 kg/ha of crawfish. 3. Sugarcane bagasse was applied twice at a rate of 2000 kg/ha each time plus 110 kg/ha of 8-8-8 fertilizer was applied 10 times. An average yield of 459 kg/ha of crawfish was obtained. 4. The last treatment consisted of two applications of 2000 kg/ha of sugarcane bagasse each, and 20 kg/ha/day of chicken manure. The average yield was 395 kg/ha of crawfish. The second study consisted of four treatments: 1. Sugarcane bagasse at a rate of 4000 kg/ha in one application gave the lowest average yield of 359 kg/ha of crawfish. 2. Chicken manure at a rate of 20 kg/ha/day gave the highest average of yield of 600 kg/ha. 3. The third treatment consisted of sugarcane filter cake at 40 kg/ha/day, and gave the second lowest average production with 370 kg/ha. 4. Sugarcane filter cake at 40 kg/ha/day plus chicken manure at 20 kg/ha/day gave the second highest average yield with 581 kg/ha.

INTRODUCTION

There are three main sources of wastes: agricultural, industrial, and domestic. Agricultural wastes originate from animals (manure, bedding, and dead animals) and parts of plants. About 60% of all wastes come from agricultural activities (17).

Among the animal wastes, livestock and poultry manure are very important because they can be used to supplement or replace inorganic fertilizers; they can also be used for poultry and livestock feed. Unfortunately in many cases these manures are not fully utilized and may cause pollution when improperly disposed.

Poultry operations in Louisiana during 1974 produced approximately 830,544 tons (dry weight) of manure (28).

The bagasse production in Louisiana during 1976-1977 was approximately 2,345,100 tons. During 1968 about 2,270,000 tons of bagasse were produced, about 70% of which was used as fuel and 30% in several by-product operations (25). In 1977 the amount of sugarcane bagasse used as fuel increased to 90% in some sugar mills due to the higher prices of fuel oil (9).

The amount of filter cake produced in Louisiana during the 1976-77 sugarcane season was approximately 257,961 tons.

Red swamp crawfish, Procambarus clarkii (Girard), comprise 90% of the total catch of crawfish in Louisiana (19), which is considered to be about 5 million kg a year (5). In 1970, de la Bretonne (6) stated that natural production varies from 2 to 5 million kg per year due to climatic factors like rainfall and temperature. During 1976, Louisiana had in operation 18,200 ha of crawfish ponds (7). The production of these ponds was 8,165 million kg which had a market value estimated at 4.5 million dollars (10).

The success of crawfish farming is due to the control that farmers have over ponds and the production. The farmer can harvest his crawfish when the market is more favorable. Another important factor is that when natural production of crawfish from the Atchafalaya Basin is low, prices are high. The crawfish farmer with his constant supply gets better profits (4, 23). In 1977 prices for crawfish were the highest in history, with $0.70 a pound in the New Orleans area. During this year, (1977) ponds produced 75% and the Basin 25% of the Louisiana total catch. In a normal year ponds produce 40% and the Basin 60% of the total crop (20).

The objective of this study was to determine production of crawfish as affected by introduction of sugarcane bagasse, chicken manure, sugarcane bagasse plus 8-8-8 fertilizer, sugarcane filter cake, and chicken manure plus sugarcane filter cake.

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[1] Research supported by Louisiana Agricultural Experiment Station and by the Office of Sea Grant, NOAA.

MATERIALS AND METHODS

Two studies were conducted at Ben Hur Farm during 1976-1978. In the first study, 16 rectangular earthen ponds approximately 0.04 ha in area and with an average depth of 1.2 m were used. All ponds were seeded with rye grass in November to provide suitable food for young crawfish at the beginning of the experiment. None contained aquatic plants to enhance the yield of crawfish during the rest of the study. It was assumed that the ponds already had crawfish present because of adequate reproduction from resident crawfish (16), and so none were stocked. Ponds were flooded during the second week of January.

Experimental ponds were randomly assigned to one of four treatments, in a completely random design. There were four ponds (replicated) per treatment. The first treatment consisted of ponds receiving a total of 4,000 kg/ha of sugarcane bagasse in two applications of 2,000 kg/ha each; the first one was made one week after flooding and the second application one month later.

The second treatment consisted of ponds receiving 20 kg/ha per day of chicken manure; it was placed inside a wooden box of 0.7 x 0.7 x 0.5 m. The top of the box was open and the bottom consisted of a screen made with 6.35 mm wire mesh galvanized hardware cloth which was in contact with the water to permit the dilution. The total amount of chicken manure received by these ponds through the study was 2,940 kg/ha.

The third treatment consisted of ponds which received a total of 4,000 kg/ha of sugarcane bagasse as in treatment one plus 10 biweekly applications of 8-8-8 fertilizer at a rate of 110 kg/ha/application.

The fourth treatment consisted of adding 4,000 kg/ha of sugarcane bagasse as in the first and third treatment, plus 20 kg/ha/day of chicken manure in wooden boxes. The total amount of chicken manure received by these ponds was 2,940 kg/ha.

To harvest the crawfish, two traps per pond (50 traps per ha) were used; these cylindrical, upright traps were constructed of mesh chicken wire with two funnel-shaped entrances around the base. The traps were baited with equal amounts of gizzard shad (*Dorosoma cepedianum*) and set for 8 to 24 hours. This type of trap is used by crawfish farmers. Crawfish were harvested on 32 occasions from March 3 to June 12, 1977.

From the flooding of the ponds until the last harvest the study lasted 150 days.

In the second study, 16 earthen ponds were used. Each pond was approximately 0.01 ha and 0.75 m in depth. Ponds were randomly assigned to one of four treatments in a completely random design; four replicates (ponds) were used per treatment: 1. sugarcane bagasse, 4,000 kg/ha in one application, 2. chicken manure, 20 kg/ha/day, 3. sugarcane filter cake at a rate of 40 kg/ha/day dry basis, 4. sugarcane filter cake, 40 kg/ha/day dry basis, plus chicken manure 20 kg/ha/day.

Ponds were flooded during the first week of November, 1977. During the second week sugarcane bagasse was broadcast on the water surface and floated for about a week; after that time the bagasse sank to the bottom. Manure in the second treatment was applied in boxes similar to the first study. In the third treatment manure and sugarcane filter cake were placed directly in the pond along one side. In the fourth treatment the sugarcane filter cake was applied directly along one side of the pond.

The chicken manure, sugarcane bagasse, 8-8-8 fertilizer, and sugarcane filter cake rates of application were selected by reviewing literature on organic fertilization and supplemental feed, specifically Hickling (13), Huet (15), and Romaire (23).

Crawfish were harvested on 20 occasions from March 11 to May 31 in the second study, using one trap per pond (100 traps per ha). This study lasted 202 days. In the second study, dissolved oxygen, water hardness, and water temperature were spot checked three times between 15:00 hrs. and 16:30 hrs. Generally water was of good quality (22).

RESULTS AND DISCUSSION

In the first study, the highest average yield of crawfish was obtained in the bagasse and inorganic fertilizer 8-8-8 treatment with an average of 459 kg/ha (308 to 687 kg/ha) (Table 1). In this treatment ponds No. 1 and 3 developed, during the cold months of February and March, a bloom of filamentous floating green algae, *Mugeotia* sp. Among these algea, diatoms were found of the genera *Rhopalodia* sp., *Fragilaria* sp., *Navicula* sp., and *Gomphonema* sp.[1] The yield of crawfish in these two ponds was 502 kg/ha and 687 kg/ha respectively.

Overall production in this treatment was higher than the treatment with bagasse only (280 kg/ha). This higher production could be due to the enhanced decomposition of bagasse by addition of fertilizer which supplied nitrogen for bacterial decomposition. Hora and Pillay (14), and Snow et al., (27), reported that as a result of increasing the availability of nitrogen for microbial decomposition, the C:N ratio of organic matter is lowered. Russell-Hunter (24) reported that detritus or particulate matter to be suitable for animal nutrition has to reach a minimum C:N ratio of 17:1. Goyert (11) in a laboratory study reported that sugarcane bagasse after a period of 12 weeks had changed its C:N ratio from 57:1 to 38:1. He also reported that bagasse after being grazed by crawfish contained the same amount of protein (3.6%) that it had before grazing.

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[1] Organisms identified by Barbara Bryan, M.S.

Table 1. Crawfish yield, in kilograms per hectare. Ben Hur Farm, L.S.U., January - June, 1977.

	Ponds						
	1	2	3	4	Ave. yield kg/ha	Ave. yield kg/pond	*
Treatments		Kg/ha					
Sugarcane bagasse	299.9	233.1	297.6	288.6	280	11.2	a
Chicken manure	402.6	264.2	563.6	521.6	438	17.5	a b
Sugarcane bagasse plus 8-8-8 fertilizer	502.4	308.4	687.6	335.7	459	18.4	b
Sugarcane bagasse plus chicken manure	332.8	459.3	295.4	491.0	395	15.8	a b

*Values followed by the same letter are not significantly different at 0.05 level according to Duncan's Multiple Range Test.

The second highest yield was from the treatment with manure alone with an average harvest of 438 kg/ha. This yield is higher than that obtained with inorganic fertilizers 281 kg/ha with 8-8-2 (26, 23). This higher harvest is probably due to the increased plankton populations obtained in the ponds fertilized with chicken manure which gave to the crawfish an available supply of food. Hickling (13) and Huet (15) have stated that manure increased the plankton populations and specially zooplankton. Avault (2), Clark et al. (4) and Romaire (23) have reported that one source of food for crawfish is the periphyton associated with aquatic plants, and that periphyton is composed of plankton and other microorganisms.

The treatment with sugarcane bagasse and chicken manure gave the third highest yield with an average of 395 kg/ha. It seems that this result was due primarily to the fertilization effect of poultry manure.

The lowest yield obtained, with sugarcane bagasse alone, is probably due to inability of the sugarcane bagasse to decay and breakdown on the bottom of the ponds during the period of the study. Goyert(11), testing the growth of crawfish fed with several agricultural by-products, found that crawfish fed with sugarcane bagasse showed the lowest growth rate. He reported that after 3 months under aquatic conditions sugarcane bagasse obtained a C:N ration of 38:1. Russell-Hunter (24) stated that the minimum required ratio for animal nutrition is 17:1.

Yields in the first study were low for all the treatments possibly because of the lateness in flooding of the ponds, which occurred in January, failing in this way to take advantage of the peaks of recruitment occurring during late October and mid-November and December (23). Another important factor is that the ponds didn't have any aquatic vegetation.

In the second study, ponds were flooded in November, taking advantage of the recruitment. In this study chicken manure gave the highest average yield with 600 kg/ha (Table 2), which is higher than that obtained in the first study for the same treatment probably because of the earlier flooding. Pond 4 developed a heavy outbreak of filamentous green algae, and its yield was 766 kg/ha. These values are between the range given by LaCaze (19) for productions of 560 to 784 kg/ha in well managed ponds with aquatic plants; the ponds used in this study did not have any aquatic plant; then the yields obtained with this treatment appear to be due to the fertilization effect of chicken manure.

Table 2. Crawfish yield, in kilograms of four treatments, Ben Hur Farm, L.S.U. November, 1977 - May, 1978.

	Ponds						
Treatments	1	2	3	4	Ave. yield kg/ha	Ave. yield kg/pond	*
Sugarcane bagasse	503.5	356.1	251.7	324.3	359	14.4	a
Chicken manure	526.2	569.3	521.6	766.6	600	24.0	a
Sugar cane filter cake	460.4	326.6	292.6	401.4	370	14.8	a
Sugar cane filter cake plus chicken manure	399.2	941.2	376.5	607.8	581	23.2	a

*Values followed by the same letter are not significantly different at 0.05 level according to Duncan's Multiple Range Test.

Sugarcane filter cake plus chicken manure gave the second highest average yield with 581 kg/ha. In this treatment, Pond 2 also developed a heavy bloom of green algae, and the total yield of this pond was 941 kg/ha (Table 2). Hickling (13) states that if liquid manure is used in strong doses, there may be a bloom of unwanted filamentous algae but also reports that bubbles of excess oxygen produced during the day are trapped in the dense algal mat which maintain aerobic conditions during the dark periods. LaCaze (19) states that large numbers of ducks over fertilize ponds and cause heavy growth of cold water algae which causes low dissolved oxygen levels resulting in suffocation of young crawfish. Avault et al. (3) reported that young crawfish may die if dissolved oxygen is below 1 ppm. Replicate 2, which was 95% covered on March 10th, 1978, had a D. O. level of 9.6 ppm at the surface and 3 ppm at the bottom. Replicate 4 of the chicken manure treatment, which was 90% covered, had a D. O. level of 18.4 ppm at the surface and 17.2 ppm at the bottom.

None of the ponds which developed outbreaks of filamentous algae showed stress conditions that could harm the crawfish population inside of the ponds, and no crawfish kills were observed during the study.

The combination of filter cake and chicken manure seems to be an adequate mixture to improve crawfish yield. Hickling (13) cites several examples of fish-growing operations in which a mixture of plant material and manure are used to increase pond production.

Sugarcane bagasse and sugarcane filter cake gave similar yields 359 and 370 kg/ha respectively, but it seems that sugarcane filter cake was slightly better to improve crawfish production.

Throughout the second study no depletion of oxygen was observed; the lowest D. O. value was 4.0 ppm, well above the critical value of 1 ppm reported by Avault et al. (3).

Water hardness was not a limiting factor in this study. The values of 86 ppm to 104 ppm were well above the minimum requirement of 17 ppm reported by Smitherman et al. (26), and above the 50 ppm level at which de la Bretonne (6) reported good growth and survival of red swamp crawfish.

CONCLUSIONS

In both studies, ponds contained virtually no natural food in the form of aquatic vegetation. Therefore, the materials added were not supplemental per se, but were the only foods available. Overall, production in both studies was mediocre. It still seems best to plant or to encourage growth of aquatic vegetation in ponds. With this and good management, production of 1000 kg/ha can be realized. The addition of sugarcane wastes and poultry manure is justified, however, when all the natural plants are depleted by crawfish. In this case the wastes would serve as a stop-gap method for providing food. If bagasse is used, it will probably be necessary to add poultry manure or a nitrogen fertilizer to lower the C:N ratio.

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SILAGE MADE FROM SUGARCANE BAGASSE TREATED WITH SODIUM HYDROXIDE

Henry J. Andreis and Ronald P. DeStefano
First Assistant and Chief Chemist
Research Department
United States Sugar Corporation

ABSTRACT

This report details the production of a palatable bagasse-based silage of a good keeping quality.

In a feed trial carried out to assess animal performance and silage acceptance, steers consumed up to 45 lbs/day of the silage. Compared to identical silage made from untreated bagasse, the sodium hydroxide treated bagasse silage was more palatable, produced better gains, had a lower feed conversion factor, and reduced consumption of molasses and mineral.

INTRODUCTION

Bagasse, the residual material obtained from the crushing and milling of sugarcane, has been found to have a number of uses in the sugar-producing areas of the world. Probably the most important use is as fuel for sugar mill boilers, though bagasse also serves as a raw material for the manufacture of particle board, paper, furfural, and animal feeds. In Florida, bagasse feed pellets are widely used as a roughage supplement for confined animals, especially dairy cattle (4, 11). However, the potential for large scale use of bagasse to improve the economics of beef cattle production has not yet been realized. Our studies center on the development of a bagasse-based silage of good keeping quality which is palatable to cattle and produces an adequate rate of gain. In addition to bagasse and molasses, this silage contains urea as a source of crude protein and sodium hydroxide (NaOH) to increase bagasse digestibility.

The use of sodium hydroxide, commonly known as caustic soda, to improve the digestibility of roughage feeds dates back to 1884 (14). It has been suggested by Tarkow and Feist (16) that sodium hydroxide acts on the lignocellulose fraction of the fiber, causing increased swelling of treated materials in water and greater penetration by rumen microorganisms. Early workers treated roughages by soaking in a dilute solution of sodium hydroxide, washing the treated residue with water and finally drying the material (6, 3, 15). When bagasse was treated by soaking for 24 hours in 2% NaOH solution, washed and sundried (12), the crude fiber digestibility was increased from 37 to 67%. The overall dry matter digestibility was similarly increased from 32 to 51%.

The washing step, however, has been criticized because of the possible removal of water-and alkali-soluble nutrients (10). The drying step is also costly, especially for a roughage type feed. Finally, the whole procedure is very time-consuming. An improved procedure investigated by Wilson and Pigden (17) and later by Donefer (5) involves adding the sodium hydroxide as a concentrated solution and omitting washing and drying. Increased intakes and improved average daily gain have been repoted for animals fed rice straw (7), corn cobs (13), corn husklage (9), or bagasse silage (2) treated by this method.

Improving digestibility and palatability to ruminants and devising a means of inexpensive storage would be helpful in making bagasse an economical feed, especially in sugarcane producing areas. The data presented in this paper indicate the aforementioned objectives can be accomplished.

PROCEDURE

Since a relatively large amount of bagasse had to be treated and ensiled for a feeding trial, special equipment was required. A style B Model B-210 horizontal batch mixer (Sprout-Waldron, Muncy, PA) having a capacity of 268 cubic feet was employed. The mixer contained a special agitator designed to handle bagasse, and was powered by a 40 h.p., 1,800 RPM electric motor with a reduced drive of 16 RPM.

One-ton batches of bagasse (55± 3% moisture) were loaded by conveyor and uniformly sprayed with 5% NaOH (dry matter basis) in the mixer. The NaOH was applied in a diluted form (approximately 5% NaOH) to obtain maximum coverage. After a 20 minute reaction period, blackstrap molasses (22% moisture) containing urea was applied similarly in sufficient additional water to obtain the desired final moisture (60%). Molasses and urea were applied at rates of 15% and 0.8% wet weight basis, respectively. While the molasses was being mixed with the bagasse, whole corn was added at a rate of 12% wet weight basis. Control silage was made in the same manner, but the NaOH was omitted.

To minimize expenses, silage was packed in large plastic bags (8 feet in diameter and 40 to 60 feet long) by an Eberhardt Silopress (Model 401). Storage capacity of the plastic bags (with normal packing) was approximately 0.9 ton per linear foot. A total of 12 bags of silage (391 tons) was prepared for the feeding trial. Excessive spoilage due to slow removal from open bags was prevented by discharging CO_2 into resealed bags after removing the desired quanitity of silage.

Both the NaOH treated and control mixtures were fermented 4-6 weeks prior to the start of the feeding trial. Before feeding, all silage mixtures were analyzed for moisture, ash, protein, fat, fiber, NFE, and pH by AOAC methods[1]. Data on acid detergent fiber, neutral detergent fiber and 72% sulfuric acid lignin were obtained and used to estimate organic matter digestibility (8). Crossbred Charolais type steers averaging 575 pounds at the start of the trial were fed for 182 days. Animals were divided into four groups as follows: group 1 (36 steers) received free choice silage containing 12% corn plus cracked corn (20% average), group 2 (36 steers) received free choice silage containing 12% corn plus cracked corn (14% average), group 3 (36 steers) received free choice silage containing 12% corn, and group 4 (6 steers) received free choice silage containing 12% corn but made from bagasse not treated with NaOH. For direct comparison to the six animals in group 4, six animals similar in size were selected from each of the first three groups. All animals received cottonseed meal (1.5 lb. per day), free choice molasses and free choice minerals. Animals were individually weighed every 28 days with the exception of the last period (14 days).

RESULTS AND DISCUSSION

During the feeding trial, several cold fronts preceded by rain caused the pens to become quite boggy and put the animals under stress. The poor pen and weather conditions caused a temporary reduction in feed consumption, and a few animals became sick. However, there were no lasting detrimental effects. The animals accepted the silage made with NaOH treated bagasse quite readily and within 3 weeks were consuming over 25 pounds per day. The animals fed silage made from untreated bagasse accepted the feed but consumed considerably less (approximately 12 pounds per day). As increasing quantities of cracked corn were added to rations fed groups 1 and 2, silage consumption was reduced. Silage consumption increased to over 45 pounds per day for the group of animals fed only silage made from NaOH treated bagasse. Near the end of the trial, the animals fed untreated silage increased consumption to nearly 40 pounds per day for a short period.

Average daily gain was quite low for all groups of animals and ranged from 0.96 pounds for animals fed untreated silage with no additional corn to 1.79 pounds for those fed NaOH treated silage with an average of 14% cracked corn added (Table 1). Animals fed silage made from treated bagasse without additional corn gained 1.56 pounds per day. The nonsignificant improvement in daily gain for animals fed the additional corn appeared to be caused by the passage of undigested corn. Possibly the large volume of roughage the animals ate moved the corn through the digestive tract too rapidly for proper digestion. Animals fed silage made from untreated bagasse (control group) gained significantly less per day than animals fed silage made with treated bagasse. The control group consumed 22% less silage, 168% more molasses, and 87% more mineral than the group of animals fed the silage made from NaOH treated bagasse. Silage made from the treated bagasse was more palatable than the control silage as evidenced by the substantial increase in voluntary consumption of the former. In addition, when a small portion of silage made from treated bagasse was placed in a feed trough full of control silage, animals that had not been eating at the time rapidly located the small portion of added silage and ate it with a great deal of zest.

Table 1. Feeding Trial Performance Data for Charolais Type Steers Fed Four Different Bagasse Silage-Based Rations

Item	Group			
	1	2	3	4
Average Initial Wt. (lb.)	575	575	575	572
Average Final Wt. (lb.)	890	900	858	739
No. Days on Feed	182	182	182	174
Average Wt. Gained (lb.)	315	325	283	167
Average Daily Gain (lb.)	1.73 a(1)	1.79 a	1.56 a	.96 b
Silage Consumed/Hd./Day (lb.)	27.0	28.8	40.8	31.8
Corn in Silage Consumed/Hd./Day (lb.)	3.2	3.5	4.9	3.8
Added Corn Consumed/Hd./Day (lb.)	7.4	5.4	---	---
Total Corn Consumed/Hd./Day (lb.)	10.6	8.9	4.9	3.8
CSM Consumed/Hd./Day (lb.)	1.49	1.49	1.49	1.39
Molasses Consumed/Hd./Day (lb.)	1.85	1.97	1.91	5.12
Mineral Consumed/Hd./Day (lb.)	0.20	0.22	0.286	0.536
Total Feed Consumed/Hd./Day (lb.)	37.74	37.66	44.20	38.31
Feed Conversion (Dry Matter Basis)	11.61	10.68	12.29	18.74
Dressing %	60.2	60.6	58.5	57.1

(1) Average gain per day figures followed by the same letter are not significantly different from each other at the .05 level.

Feed analyses (Table 2) show that protein, fiber, NFE, fat and pH are similar for treated and control silages. Ash is considerably higher for the treated silage due to increased sodium from the added NaOH. While the fiber content may not have changed due to NaOH treatment, composition of the fiber most likely did change (e.g., lignocellulose bond breakage (16). The slightly higher crude protein in the control silage may be due to contamination from urea added to the mixture with the molasses. Chemically determined organic matter digestibility (OMD) was approximately 3.7% higher for silage made with NaOH treated bagasse. Treating bagasse with 5% NaOH (dry bagasse basis) has been shown to increase OMD from 38.8 to 52.9% (unpublished data). However, improvement of OMD in bagasse is largely masked due to the addition of highly digestible molasses and corn.

Table 2. Proximate Analyses of Bagasse Silages Containing 12 Percent Corn

	Treated Silage(1)		Control Silage(2)	
	As Rec'd	Dry Basis	As Rec'd	Dry Basis
% Protein	5.06	12.66	5.59	13.97
% Ash	5.14	12.86	2.68	6.69
% Fat	.56	1.39	.66	1.64
% Fiber	8.15	20.38	8.14	20.63
% NFE	22.01	55.04	22.61	56.52
% OMD	---	64.14	---	60.42
pH	4.26	----	3.70	----

(1) Silage made with NaOH treated bagasse.
(2) Silage made with untreated bagasse.

The treated silage not only was more palatable as demonstrated by increased consumption, but was also more digestible as evidenced by a better conversion factor for total dry matter consumed (12.29 compared to 18.74 for the control). As might be expected, animals receiving the additional corn in the ration had higher dressing percentages (Table 1). Dressing percentage was lowest (57.7) for the control steers. All steers not receiving additional corn graded standard. In contrast, the group receiving 14% additional corn had 3 standards and 3 goods, and the group receiving 20% additional corn had 5 standards and 1 choice. It is likely that considerably more steers would have reached the higher grades had the feeding trial continued for an additional 30-60 days. It should be pointed out that all rations contained a relatively low level of corn for fattening steers (28.15, 23.55, 11.09 and 9.92% for rations fed groups, 1, 2, 3, and 4, respectively). Analyses conducted on liver, kidney and muscle tissue indicated very little if any increase in sodium due to NaOH treatment (Table 3). Muscle, the tissue of primary interest, had the lowest sodium content of the three types of tissue analyzed and had no significant increase in sodium due to the NaOH treatment.

Table 3. Tissue Sodium(1)

	Milligrams per 100 Grams(2)		
	Liver	Muscle	Kidney
Control Silage (no NaOH)	70.5 a	42.3 a	146.6 a
Silage (NaOH treated)	76.0 a	48.1 a	167.3 b
Silage (NaOH treated) + 14% Corn	70.7 a	43.4 a	170.9 b
Silage (NaOH treated) + 20% Corn	73.1 a	43.7 a	172.4 b

(1) Analyses conducted by the Animal Science Department, University of Florida.
(2) Means followed by the same letter are not significantly different at the .05 level.

Silage made from bagasse treated with 5% NaOH on a dry basis was significantly superior to silage made from untreated bagasse; it was more palatable, produced a higher daily gain, reduced consumption of both molasses and mineral and had a lower conversion factor than the control silage. However, additional corn compatible with the silage (i.e., high moisture corn) will be required to obtain adequate daily gains, higher dressing percentages and higher carcass grades. Further work in this area is presently in progress and results at this time are encouraging.

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THE COMPARATIVE REPRODUCTIVE CAPACITY OF SEVERAL BROADLEAF WEEDS AND GRASSES FROM SEED IN LOUISIANA

Ernest R. Stamper
Department of Plant Pathology
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

The yields of pounds or tons per acre of several weeds have been reported over a period of years. Some of the plants studied reproduce from both rhizomes and seeds; others reproduce from seeds only. In this study only plants which reproduce from seeds were included. The seed reproduction from ten plants in the sugarcane growing area of Louisiana are reported and the number of seeds from each plant is shown in Tables 1 to 10. Five plants from five different locations were used in making the determination of seed per plant. The study was made for a period of two years and there was very little variation in the number of seed produced in 1976 and 1977.

The two pigweeds, Amaranthus retroflexus and Amaranthus spinosa, were the largest seed producers per plant. These two were followed by in the order of reproduction: 3 - Browntop panicum (Panicum fasiculatum), 4 - crabgrass (Digitaria saguinalis), 5 - wild lettuce (2 species used and both were about equal in seed production, 6 - goosegrass (Eleusine indica), 7 - aster (2 species or varieties approximately the same in seed production), 8 - johnsongrass (Sorghum halepense), 9 - signalgrass (Brachiaria sp.), 10 - itch or Raoulgrass (Rottboellia exaltata).

INTRODUCTION

A herbicide program has been used in the Louisiana sugarcane belt since 1946. The specific weed for which money was appropriated to control is no longer considered to be a problem in sugarcane. This weed was alligatorweed (Alternanthera philoxeroides). The main source of reproduction of the alligatorweed was from roots, stems, and rhizomes; seeds were not a problem in reproduction. This plant was practically eliminated from sugarcane with 2,4-D. Other plants that were susceptible to 2,4-D were controlled to some extent but some continue to be a problem. One plant that has not been controlled is morningglory which is reproduced mainly by seed and the seed remain viable in the soil for over 30 years.

As time continued on and observations were made of the weeds and grasses growing in the sugarcane fields it was apparent that some were being controlled and others were becoming more numerous. The increase in number in most cases was due to the inability of the chemical weed control material to kill a certain group of plants within the species as previously recognized.

At a glance, it would seem that these plants had become resistant to the 2,4-D or any other herbicide where this might occur. In many cases this is not true because the plants were never susceptible and continued to produce seeds and increase rapidly.

Other plants began to occur in the sugarcane fields that had never been observed until the shift in the use of herbicides began. Among these plants were the wild lettuce, asters, morningglory, browntop panicum and possibly others. Upon first observation of some of these plants there were only a few scattered clumps in the field; however, later the infestation was heavy in these areas.

It was from these observations that some studies were made as to the ability of certain plants to reproduce seed and reproduce plants from a single seed. It had also been observed that some plants were easy to control and others were difficult to reduce the population from year to year.

Pig weed (Amaranthus sp.) was always abundant the year following a good control system when compared with some other broadleaf plants. Apparently this was because of the tremendous buildup of seed in the soil (Tables 1 and 2).

The same observation follows in that itchgrass is relatively easy to obtain a high level of control because of the small number of seed reproduced from one seed (Table 10). Itchgrass has been successfully eliminated on several plantations when the infestation was found in the early stages of development.

Other plants such as the browntop panicum poses more difficult problems because it is highly resistant to some of the chemicals used for general weed and grass control in the sugarcane belt. While it is highly resistant to Sinbar it is very susceptible to Fenac. Combinations of these two chemicals are suggested for the control of browntop panicum where it is known to occur.

SUMMARY

Data are presented on ten plants that are common in the Louisiana sugarcane growing area. The tables show the number of seed from each plant in descending order with the two species of pigweed at the top and itchgrass at the bottom.

The data were collected from five plants not growing in the cultivated crop, but in isolated conditions. Five plants from each of five plantations were used in the study. The study was made for two years and the mean average is shown for each of the ten plants.

Very little variation occurs from the number of seed produced in the two-year period on different plantations.

The number of seed produced from one plant (one seed) in 1976-1977 on five different plantations in the sugarcane belt. Five plants used for each plantation.

Table 1. Amaranthus retroflexus (pigweed).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	3840	21	35	2,822,400
2	3622	23	31	2,582,486
3	2721	26	37	2,617,602
4	3913	22	31	2,668,666
5	3102	21	23	1,498,266
Mean average	3440	23	31	2,437,884

Table 2. Amaranthus spinosa (spiny pigweed).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	2880	30	24	2,073,600
2	2654	26	28	1,932,112
3	3401	27	32	2,938,464
4	3008	25	27	2,030,400
5	2703	29	27	2,116,449
Mean average	2929	27	28	2,218,205

Table 3. Panicum sp. (Browntop panicum).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	51	30	46	70,380
2	53	20	54	57,240
3	60	19	53	60,420
4	37	24	47	41,736
5	52	26	46	62,192
Mean average	51	24	49	61,606

Table 4. Digitaria sanguinalis (Crabgrass).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	55	8	137	60,280
2	60	9	107	57,780
3	52	8	158	65,728
4	67	8	98	52,528
5	51	7	103	36,771
Mean average	57	8	121	54,617

Table 5. Wild lettuce (2 species about the same) (Lactuca sp.).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	45	70	8	25,200
2	48	67	8	25,728
3	47	72	9	30,456
4	50	70	8	28,000
5	51	75	8	48,600
Mean average	48	71	8	31,596

Table 6. Goosegrass (Eleusine indica).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	24	5	167	20,040
2	28	4	134	15,008
3	26	5	143	18,590
4	32	6	169	32,448
5	37	7	157	40,663
Mean average	29	5	154	25,350

Table 7. Aster (2 species about the same).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	-	45	52	23,400
2	-	39	57	22,230
3	-	38	50	19,000
4	-	47	61	28,670
5	-	36	30	10,800
Mean average		41	50	20,820

Table 8. Johnsongrass (Sorghum halepense).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	18	18	25	8,100
2	19	45	17	14,530
3	9	32	24	6,912
4	11	26	32	9,152
5	14	47	16	10,528
Mean average	14	34	23	9,844

Table 9. Signalgrass (Brachiaria platyphylla).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	26	3	17	1,326
2	24	4	17	1,632
3	22	3	18	1,188
4	26	5	22	2,860
5	25	4	22	2,200
Mean average	25	4	19	1,841

Table 10. Itch (Raoul) grass (Rottboellia exaltata).

Plantation number	Number heads or limbs	Number spikelets per head	Number seed per spikelet	Number seed from one plant
1	8	-	18	144
2	6	-	24	144
3	6	-	23	138
4	8	-	20	160
5	9	-	21	189
Mean average	6	-	21	155

EXPERIENCES WITH STANDOVER CANE DURING THE 1977-78 SEASON OF THE RIO GRANDE VALLEY SUGAR GROWERS

Norman Rozeff
Rio Grande Valley Sugar Growers, Inc.
Santa Rosa, Texas

ABSTRACT

The events leading to the standing over of 5,600 acres of sugarcane, normally harvested at one year of age, are reviewed. Cultural practices on the standover cane are noted. Cane condition at harvest and machine harvesting difficulties are recounted. Guidelines for handling future crops facing a similar situation to the 1976-77 crop are derived from this experience.

INTRODUCTION

When harvesting commenced on October 14, 1976, there was little to indicate that this would turn out to be the most challenging campaign yet in the short history of the Rio Grande Valley Sugar Growers. 8.07" of rain had fallen in the month and a half before startup. Perhaps this was an unrecognized harbinger of what was to follow. On October 24, valley-wide rains commenced. A total of 4.6" over a six day period so saturated the fields that harvesters were not able to start operations again until November 8. Even so, field moisture conditions were marginal. We were able to cut, load and transport only in the better drained sandy loam fields. On November 12, rains recommenced. A total of 3.57" fell during the remainder of the month. This was 2.5 times the 60 year average for this month. It exceeded the monthly Class A pan evaporation by .85".

On December 7, an effort was made to harvest in the driest of the Valley fields. This proceeded fitfully until the 13th when daily showers over a 15 day period totaling 1.29" shut us down again. By this time, pan evaporation rates had dropped to .07" daily. The cold weather slowed cane metabolism, growth and evapotranspiration, so the cane itself was doing little to reduce soil moisture.

Through January 9, a mere .3" fell. This encouraged another startup on the 10th. Grinding lasted all of 1 1/2 days when showers on the 11th stopped us again. 1.42" fell during the remainder of January and 1.31" through the first 13 days of February.

Only by February 23 were we able to venture into the fields again. This time the rains moved elsewhere. With warmer weather and only 2.36" of rain total through June 10, we were able to get on with the formidable harvest job remaining. On June 12 and 13, 3.25" of rain plus the prospect of reduced crop age for next season's crop brought us to the decision to stop grinding on the 15th.

A total of 2,615 hours or 109 days had been lost due to rain. The campaign lasted 2 1/2 months more than scheduled. 27,055 acres with 1,074,837 tons had been harvested, but an additional 2,823 acres were abandoned due to inability to harvest. Finally 5,577.42 acres of cane were not harvested at all. This latter presented us with a unique situation, a situation for which we had no precedent.

Each season the valley cane is subjected to some degree of frost damage. Fortunately, for the 1976-77 season, the dangers of freeze were not superimposed upon the rain-delayed harvest, otherwise the crop loss would have been horrendous.

On January 10 and again on the 19, mild freezes did occur, but the damages sustained were mostly to the tops and apical meristem. Serious internal damages from the 29° F lows were rare and mainly confined to the western end of the valley where soil conditions allowed harvesting before measurable deterioration losses occurred.

Cane varieties grown in the valley are selected for their ability to put on fast growth and reach acceptable sucrose levels during a 12 month calendar period. When we carried over approximately 5,600 acres of cane, we subjected this cane to a growth period of 18 to 27 months.

Growers with standover cane were asked to keep this cane alive, but with minimal care. The object was to keep subsequent cane tonnages to a harvestable level. "Minimal care" meant many things to many people. To some, it meant no irrigation, no borer control, no fertilization. To others it meant only something slightly less than the normal care of the regular crop. Most growers kept to the low side, that is, one to three irrigation rounds, 0-50 lbs. nitrogen fertilizer per acre, and one to three borer control applications.

Soil type, natural rainfall, and grower handling practices combined to give us a wide spectrum of cane growth and quality. Only 15.6" of rain fell between May 1, 1977, and November 30, 1977. 7.61" of this fell in June. Had it been a wet summer, the results from standover cane may have been far worse than that experienced.

Freeze damage the winter of 1976-77 had an influence. The eastern third of the valley nearest to the Gulf of Mexico sustained spotty cane damage. In the western two thirds, top kill was nearly 100% while in the eastern third, damage was about 40% or even less as one approached the coast.

The death of the apical meristem physiologically stimulated sideshooting and the production of lalas. This sideshooting of lateral buds kept the first year cane stalks alive and, in many cases, produced three or four lalas with millable cane averaging 18" each in length.

Unfortunately, the low price of sugar in 1976 and 1977 forced many growers to skimp on borer control, especially late in the season. Borer infestations were often of high incidence in the cane tops. Come spring, overwintering borer population escalated in the lala tops.

The souring original tops also attracted borers which often prefer this condition. When it was realized that we would carry over cane, we urged our growers to spray cane scheduled for a June 1 or later harvest. Azodrin was recommended as a strong remedy for the high populations. Many growers ignored this recommendation. As a result, lalas were being continuously bored. This reduced their growth and hindered translocation of sugar. As a result, fields in this state reached a plateau where little additional tonnage was accumulated and cane did not lodge badly. The new tops under these circumstances barely sustained the plants.

Where cane tonnage was already heavy at the end of the 1976-77 season and where lalas had considerable growth, the first year cane growth lodged nearly 100%. This condition opened the base of the stool to sunlight and also physiologically stimulated a second season sucker growth. In some instances, the lodging occurred in the spring and in others, in the summer. As a result sucker length varied from field to field. With an established and extensive root system, the standover fields which lodged early produced a second year crop of suckers nearly equal in tonnage to first year cane. These suckers, especially those of NCo 310, exhibited exceptionally large stalk diameters and internodal lengths.

Toward the end of September, the recumbent first year cane began to be covered with leaf trash from the second year suckers. Where the second year sucker population was high, the first year cane could not sustain enough top growth as it suffered from shading and physical inundation by leafy trash. As a result, the first year cane started to die back from the tops. At this juncture, they were unable to build and translocate additional sugar. In cases where varietal or growth conditions were less favorable for trash and suckers, the lalas of lodged cane turned upward from the ground and reached lengths of three feet.

In October, then, we were confronted with cane that had low to moderate sugar levels in both suckers and first year cane. Those fields which were poorly cared for in regard to borers during the first year of growth began to exhibit pithiness, tissue shrinkage, and souring. They were on the decline phase and would not improve as the season progressed.

Rodent damage, which generally is minor in the valley, was noted to be higher but still played a minor role in overall cane quality.

There were varietal differences noted in the standover cane. CP 44-101 showed more frost damage than NCo 310. It exhibited a greater degree of top dieback and drying out. With less potential for tonnage, growers did less with it than the other varieties.

NCo 310 was the variety with the most rigorous second year growth. We observed in the late harvested 1976-77 cane that NCo 310 peaked in pol and purity in mid-April and was able to sustain this level through the end of the season.

This may be indicative that NCo 310 under certain climates has a natural physiological maturity around 18 months in length.

One field of CP 52-68 was close behind NCo 310 in second year growth. CP 61-37 was intermediate in second year growth. Since it matures earlier, the reduced number of suckers plus maturity of first year cane gave it the best juices of standover cane harvested in mid-October.

Table 1. Yield information for the major varieties harvested during the 1977-78 season.

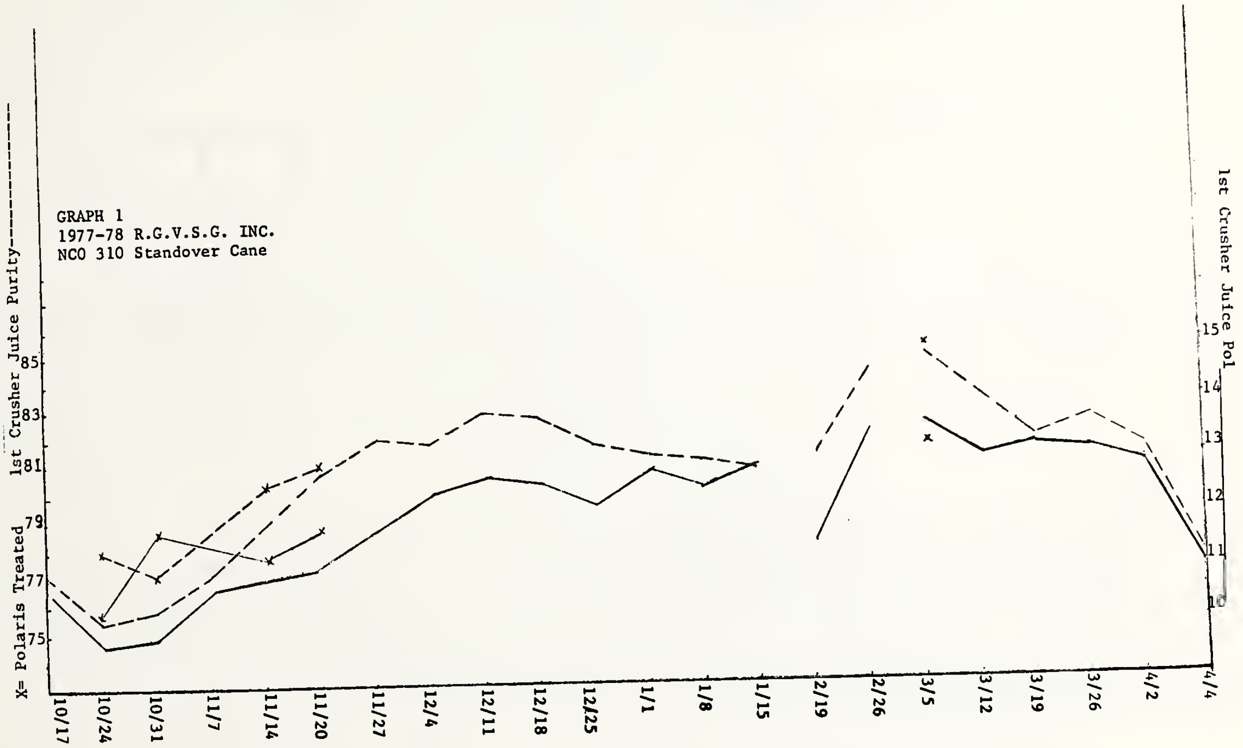
Variety	Status	Total Acreage	Brix	Normal Juice Pol	Normal Juice Purity	Net TCA	% Trash	Yield % Cane	TSA
CP 61-37	1 year	4,776.68	15.59	12.66	81.20	25.1	14.39	9.39	2.33
CP 61-37	Carryover	348.20	14.77	11.42	77.31	37.8	11.30	7.95	3.02
CP 52-68	1 year	3,234.34	16.11	13.04	80.94	25.8	13.68	9.57	2.46
CP 52-68	Carryover	75.00	15.35	12.04	78.43	34.2	14.25	8.77	2.87
CP 44-101	1 year	393.49	15.92	12.89	80.96	15.4	9.90	9.05	1.40
CP 44-101	Carryover	648.60	14.41	11.00	76.33	32.4	11.19	7.61	2.44
NCo 310	1 year	9,772.49	16.58	13.66	82.38	27.9	10.34	9.74	2.69
NCo 310	Carryover	3,526.68	14.35	11.14	77.63	48.5	10.86	7.74	3.74

The cane fires in carryover fields were excellent. This is reflected in the lower trash percent values. Values were lower despite the fact that dead, dried-out cane was counted as trash and, of course, was more prevalent in the carryover cane than one year cane.

The trash figures for NCo 310 are misleading. Most of the carryover 310 was harvested the first part of the season. Most of the one year 310 was harvested after the seasonal freezes. Freezes dessicate the tops and burns are considerably better resulting in a trash reduction. NCo 310 one year cane harvested before the January 11 freeze averaged 15.79% trash while carryover cane harvested before this date averaged 11.41% trash.

It is obvious that juice quality suffered in carryover cane. Brix, pol and purity levels were all down from one year cane results. Tonnages on the other hand were up 50.6, 32.6, 110.4, and 73.8% respectively for CP 61-37, CP 52-68, CP 44-101, and NCo 310. Tons sugar per acre did not rise proportionately to cane tonnage because of the poorer juice quality. Tons sugar per acre were up, however, 29.6, 16.6, 74.3, and 39.0% respectively for 37, 68, 101, and 310.

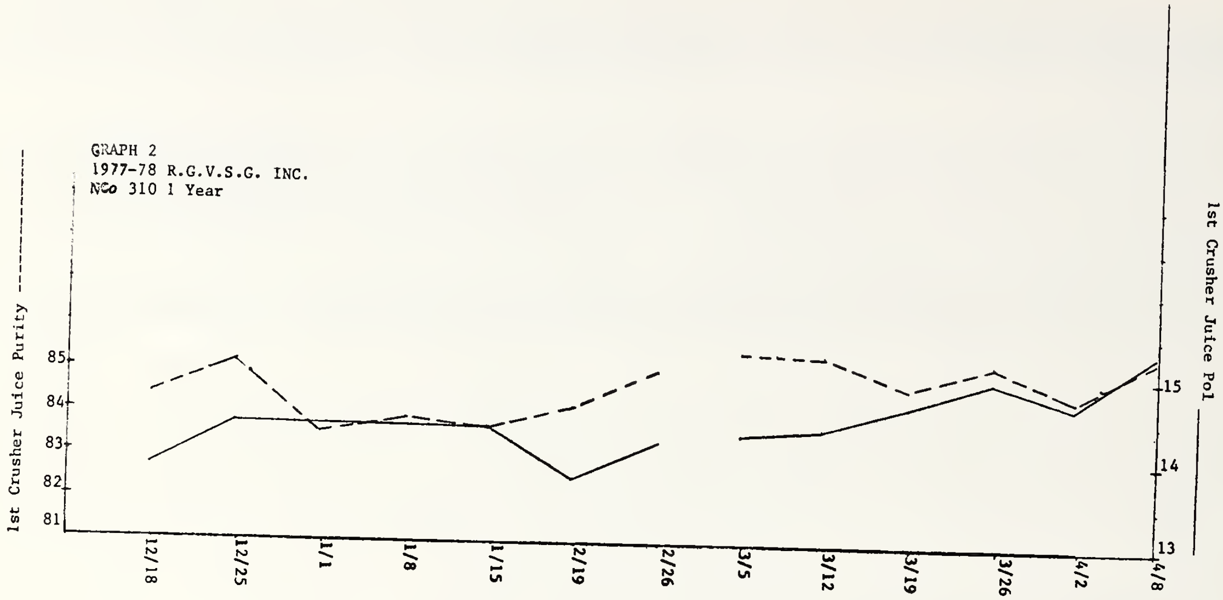
Graph 1 plots the weekly juice quality for standover cane. A more or less normal ripening curve for NCo 310 is noted. The sharp drop at the end of the season reflects harvest of a diminished number of fields which were in poor shape with considerable dead and dying and composting stalks.



Graph 2 plots the one year 310 cane. Since the harvest of this type cane started later in the campaign, the sharp incline in juice quality usually noted is not observed. Yet pol did, on an average, steadily increase 1.4 points from December 18 through April 8.

The maturing of second year suckers in the 310 appears to have partially offset the decline of cane quality due to stalk deterioration. The results of Polaris cane ripener applied fields are also noted in Graph 1. The graph clearly indicates that Polaris was beneficial early in the season when second year suckers were still immature. One late season harvest of a Polaris-treated field showed no benefit over untreated cane. By this time, second year suckers had matured naturally.

The conclusion drawn from cane ripener results was that each carryover field to be potentially treated should have been surveyed for an estimation of second year sucker population and size. Fields which had plateaued with very little second season growth were least likely to beneift from a cane ripener application.



From six NCo 310 microplots, samples were collected prior to harvest in order to determine the vegetative constituents percent by weight. The averages from the six samples (all taken prior to February 1) showed the following makeup by %.

dry trash	green trash	dead stalks	dying stalks	second year suckers	good first year cane
11.11	13.66	.96	1.96	16.90	55.41

The question arises concerning harvesting strategy. Would it have been wiser to harvest the 310 standover later in the season? The question is not moot for two reasons. One: we did not know if increasing second year sucker maturity would offset continuing stalk deterioration, nor were we readily able to monitor the ratio of suckers to first year cane. Second: after the start of the season, it soon became apparent that any harvest machine other than the CLAAS 1400 and TOFT 364 would be unable to handle the tonnages which were to be encountered. After one month of harvesting when heavy tonnage fields nearly demolished the Massey-Ferguson 201(s) and Toft 300(s), they were withdrawn. The remainder of the carryover fields were harvested by the four high capacity harvesters. This took the remainder of the season, less two days. In short, no leeway was available to schedule carryover fields on their maturity potential; we needed all the allowable time to get this cane harvested.

The gross tons cane per acre of NCo 310 fields averaged 54.37 with several fields above 80 TCA. The top yielding field of 310 grossed 86.5 TCA. Millable scrap left in the standover fields ranged from 3.5 tons through 15 tons per acre. Even after burning, we may have been dealing with gross tonnage, in some fields, approaching 100 tons per acre.

During the latter part of the 1976-77 season when it was realized that we would have both late harvest and carryover cane, some thought was given to the alternative of burning and shredding fields which would not be harvested before May 15. This would have meant a $20 per acre cost for shredding down the burned cane plus costs involved in growing a new crop.

Table 2 (following page) compares the results of three strategies.

The option for carrying over cane rather than shredding and starting a new crop saved the individual farmer some expenses in 1976-77. It did, however, shift the burden to the mill and became an added cost the following campaign. Shredding of unharvested cane would have cut additional losses approximately $30 per acre.

Table 2. Comparison of the results of three strategies.

	New Crop Each Year	Discard First Year's Crop	Carryover First Year's Crop
Year 1 1976-77 Farming Cost of Crop Per Acre	$150.00	$150.00	$150.00
Year 2 Farming Cost of Crop Per Acre with 6% Inflation Factor	129.25*	$129.25* + $20.00 to shread = $149.25	89.50
Two Year Total Farming Costs:	$279.25	$299.25	$239.50
Year 1 1976-77 Sugar & Molasses Returns Based on $18.49/Ton of Cane	39.7 GTCA x $18.49 = $734.05	-0-	-0-
Year 2 1977-78 Sugar & Molasses Returns Based on Yield % of Cane	29.7 GTCA at 8.35% x $23.40 = $694.98	29.7 GTCA x $23.40 = $694.98	50.17 at 6.86% x $19.22 = $964.27
Two Year Gross Returns:	$1,429.03	$694.98	$964.27
Net After Deducting Farming Costs:	$1,149.78	$395.73	$724.77
Year 1 1976-77 Harvest, Haul, Mill & Adm. Costs at $17.99/Ton:	39.7 x $17.99 = $714.20	-0-	-0-
Year 2 1977-78 Harvest, Haul, Mill & Adm. Costs at $17.52/Ton:	29.7 GTCA x $17.52 = $520.34	29.7 GTCA x $17.52 = $520.34	50.17 x $17.52 = $878.98
Total Production Costs for Two Years:	$1,234.54	$520.34	$878.98
Net Return (Loss) for 2 Years:	($84.76)	($124.61)	($154.21)

* The economics of sugar were such in 1977-78 that growers reduced farming inputs for sugarcane.

The production aspect to which we should have given more attention in 1976-77 was the harvesting of heavier tonnage fields. Our production rate would have benefited at that time although field acreage to carryover would have escalated. However, the tonnage in fields carried over would have been easier to handle in the 1977-78 season.

While we in Texas wish that our experience with standover cane not be repeated elsewhere, we hope that this paper will enlighten those facing such dark circumstances should they occur.

SUGARCANE JUICE QUALITY AS RELATED TO NITROGEN FERTILIZATION

J. R. Thomas and J. A. Schmidt
Soil and Water Conservation Research
USDA, SEA, AR
Weslaco, Texas

ABSTRACT

Excessive N fertilizer is a suspected cause of low-quality juice from sugarcane grown in the Lower Rio Grande Valley of Texas. However, the relation between N and juice quality has been inconsistent. In this study, we determined the influence of soil fertility and N fertilization on cane and sugar yields and the juice mineral concentration; the relation between juice quality and mineral composition; and the relative importance of several cations and anions to juice quality. Sugarcane cultivar CP 52-68 was grown at N levels of 0, 112, and 224 kg/ha on the cut and fill areas of a Raymondville clay loam (Vertic Calciustolls). The experimental design was a randomized complete block with three replications. Each plot consisted of six 381-m-long rows of cane spaced 168 cm apart. Cane and sugar yields were 22 and 18%, respectively, greater on the fill area than on the cut area. The soil's innate fertility affected the concentration of Cl, N, and P in the juice. The application of N fertilizer increased the juice cation, Cl and N concentrations. Poor quality juice (low pol and purity) was associated with large cane yields, high juice cation levels or electrical conductivity (r_{pol}=-0.90**), N (r_{pol}=0.94**), Cl (r_{pol}=-0.97**) and low amounts of P. Percentage brix and pol were only slightly depressed at juice N concentrations greater than 20 me/100g, whereas percentage pol decreased progressively as juice Cl concentrations increased.

INTRODUCTION

High rates of N fertilizer and late season N applications are suspected causes of low-quality juice from sugarcane grown in the Lower Rio Grande Valley of Texas. However, the correlations between juice quality components (pol, brix, and purity) and N fertilization have been inconsistent (15). The deleterious effects of N fertilizer on juice quality may be due to late season vegetative and sucker growth (14). High concentrations of unassimilated N compounds in the immature cane decreased polarization and sugar recovery (16). Nitrogen fertilization also may increase the ash content of the juice. Lemaire et al. (7) reported that N fertilization increased the juice Ca and Mg concentrations but decreased the P and K concentrations. Parish (12) found that juice P and K concentrations decreased when N increased cane yields. Leverington et al. (9) reported an increase in juice N concentration as the cane matured, but the effect of N fertilizer on juice N was inconsistent. Response of juice P to N fertilization changed as the cane matured and differed among sugarcane cultivars (10). Soil salinity increased the ash content of the juice and decreased sugar recovery (4).

Since the mineral composition of the juice is strongly influenced by fertilizer, climatic conditions, and the soils on which the cane is grown, juice analysis might indicate any nutrient imbalances, deficiencies, or excesses that relate to cane growth and sugar recovery. Therefore, we determined the influence of soil fertility and N fertilization on the mineral composition of the juice, the relation between juice quality and mineral composition, and the relative importance of several cations and anions to juice quality.

MATERIALS AND METHODS

A N-rate study was begun in April 1975 on second ratoon sugarcane (cultivar 'CP 52-68') on cut and fill areas of a leveled field. Soil type was Raymondville clay loam (Vertic Calciustoll). Chemical properties of the soil are given in Table 1.

Land forming probably affected the soil's capability to supply N and P to the sugarcane crop. Removal of surface soil decreased organic matter, total N, available NO_3-N, and $NaHCO_3$-soluble P concentrations in the upper 30 cm of the soil profile; and slightly increased the mean concentration of soluble cations and anions in the upper 120-cm profile depth. Growth response to N fertilizer was highly probable on the cut area, whereas the possibility of a growth response to P fertilizer was small. Soil salinity increased with profile depth. In several plots, the electrical conductivity of the saturated extract (EC_e) exceeded 4 and 3 mmho/cm, respectivly, at the 150-cm depth in the cut and fill areas.

A randomized, complete block design with three replication was used. Each plot consisted of six 381-m-long rows of cane spaced 168 cm apart. Nitrogen was sidedressed annually in March or April. A solution of urea-NH_4NO_3(32% N) was applied at N levels of 0, 112, and 224 kg/ha/yr.

Soil samples were taken from the top 30 cm for fertility characterization and at 30-cm intervals to a depth of 150 cm for salinity determination. Organic matter was determined by the Walkley-Black method; P by the $NaHCO_3$ procedure; total N by Kjeldahl and NO_3N by the nitrophenol-disulfonic-yellow method (6). Exchange capacity, EC_e and soluble cations and anions were determined by methods used at the salinity laboratory (17).

Cane was harvested during December, except for the third ratoon crop (1976) which was cut in March 1977. All the cane in the plot area was cut and weighed using factory equipment. Juice of 20 unburned stalks from each plot was analyzed for total soluble solids and apparent sucrose (11), inorganic cations (13), total P by the Bolin and Stamberg (3) and Barton (1) methods, total N by the Gunning method (8) and Cl using a Buehler-Cotlove chlorimeter.

Analysis of variance and regression techniques were used to evaluate the effects of N fertilizer on cane and sugar yields, juice quality components, and the mineral content of the juice.

Table 1. Soil tests values of the experimental sites in March 1975.[1]

Properties	Unit	Cut	Fill
CEC	me/100g	28.5 a[3]	29.4 a
pH		7.7 a	7.8 a
Organic matter	%	1.07 a	1.48 b
Total N	%	0.08 a	0.12 b
NO_3-N	ppm	1.2 a	4.7 b
$NaHCO_3$-P	ppm	6.6 a	12.9 b
EC_e[2]	mmho/cm	2.9 a	2.4 a
Soluble ions[2]			
Ca	me/1	10.7	10.9
Mg	"	3.3	2.7
K	"	0.4	0.7
Na	"	15.7	11.4
Cl	"	11.3	9.1
SO_4	"	13.7	11.7
HCO_3	"	4.0	3.6

[1] Mean values of 3 replications and 3 treatment locations.
[2] Mean values for profile depth 0 to 120 cm. All other values for profile depth 0 to 30 cm.
[3] Values in same row followed by same letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

RESULTS AND DISCUSSION

Cane and Sugar Yields

A saline water table seriously decreased the establishment and growth of the plant cane, especially in the cut area. A drainage well system activated in February 1974 effectively controlled water table depths throughout the study period; however, some of the differences in cane yields between the cut and fill areas may reflect initial differences in stand. During the 3 years (1975 through 1977), 22 and 18%, respectively, more cane and sugar were produced on the fill than on the cut areas (Table 2). With continuous cropping of nonfertilized cane, yields decreased 36.6 and 30.6%, respectively, on the cut and fill areas. Yields of N-fertilized cane decreased about 16% (compare 1975 and 1977) in the cut area, but remained at the same level in the fill area. Larger N-fertilized cane and sugar yields in 1976 reflected the 3-month longer growing season. Except for the second ratoon crop on the fill area, the application of 112 kg N/ha significantly increased cane yields over those of the nonfertilized treatment. Cane and sugar yields with 224 kg N/ha did not differ significantly from those with 112 kg N/ha.

Juice Quality

Application of N fertilizer (112 kg/ha) significantly decreased the degree of brix, polarization, and purity of the juice (Table 3) in 1975 and 1977. The longer growing season in 1976 insured more complete utilization of N in vegetative growth. The effects of land forming on juice quality were not statistically significant; however, brix, pol, and purity were lower in cane grown on the more fertile fill area.

Mineral Composition of Juice

Land forming significantly affected the P concentration of the juice in 1975 and 1977, and the Cl and EC (electrical conductivity) in 1975 (Table 4). The juice P concentrations increased as the availability of P in the soil increased (r=0.64*). Juice N concentrations of 8.2 and 11.6 me/100g, respectively, on cut and fill areas of nonfertilized cane reflected differences in the soil's innate ability to supply N, whereas in N-fertilized cane, the higher juice N concentrations on the cut area were associated with the smaller yields.

Juice Cl concentration was influenced by the NO_3-N and Cl levels of the soils at growth initiation. The coefficient of determination x 100 suggested that variation in the soil N and Cl levels accounted for 79% of the juice Cl variability on the nonfertilized soils. Standard partial regression coefficients ($b'_{YN.Cl}=0.70$, $b'_{YCl.N}=0.60$) indicated that soil N and Cl levels were almost equally effective in determining the juice Cl concentration.

Table 2. Sugarcane yields as affected by N fertilization and land forming.

N applied	Crop cycle	Cane		Sugar	
		Cut	Fill	Cut	Fill
Kg/ha		Metric tons/ha			
		1975			
0	2nd Rtn	68.1 a[1]	97.5 c	8.31 a	10.51 c
112		88.3 b	101.2 c	9.65 bc	9.88 c
224		83.8 b	98.6 c	8.76 b	10.26 c
Mean		80.1	99.1	8.91	10.22
		1976			
0	3rd Rtn	50.2 a	79.7 b	6.05 a	10.12 b
112		92.7 c	101.0 c	11.22 b	11.33 b
224		92.3 c	104.6 c	11.27 b	11.65 b
Mean		78.4	95.1	9.51	11.03
		1977			
0	4th Rtn	43.2 a	67.7 b	5.51 a	7.48 c
112		72.9 b	101.4 c	6.90 b	10.53 d
224		70.9 b	95.3 c	6.89 b	9.14 d
Mean		62.3	88.1	6.43	9.05

[1] Yields in same year followed by same letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

Table 3. Sugarcane juice quality as affected by N fertilization.

N applied	Crop cycle	Brix	Pol	Purity
Kg/ha			%	
			1975	
0	2nd Rtn	19.0 a[1]	15.9 a	83.7 a
112		18.2 b	14.7 b	80.8 b
224		18.4 b	14.8 b	80.4 b
			1976	
0	3rd Rtn	18.8 a	16.3 a	86.7 a
112		18.7 a	16.2 a	83.6 a
224		18.6 a	16.1 a	86.6 a
			1977	
0	4th Rtn	19.7 a	16.5 a	83.8 a
112		17.8 b	14.2 b	79.8 b
224		17.8 b	13.9 b	78.1 b

[1] Values in same column followed by same letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

Application of N significantly raised juice Ca, Mg, K, and Cl concentrations (Table 5). Juice N concentration increased (r=0.97**) and P concentration decreased as N fertilizer level increased. The P concentration was reduced more than could be accounted for by the increase in cane growth. The application of 112 kg N/ha increased cane yields 25% over those of the nonfertilized cane, but reduced juice P concentration 51%. The juice P concentrations were a function of the available soil P and applied N. Standard partial regression coefficients ($b'_{YP.N}=0.38$, $b'_{YN.P}=-0.77$) indicated that N was twice as effective as available soil P in determining the juice P concentration. The coefficient of determination x 100 suggested that soil P levels and N fertilizer rates accounted for 84% of the variability in juice P concentrations. The P values may be too low for clarification of the juice. Leverington et al. (1965) suggested that 80 ppm total P was the lower limit.

The greater concentration of cations in the juice following N fertilization raised the electrical conductivity (EC). The correlation between EC and the sum of the cations (Ca + Mg + K + Na) was highly significant (r=0.94**). The juice EC was not related to the EC_e of the soil solution.

Table 4. Effects of land forming on mineral contents[1] of sugarcane juice.

Mineral constituents		1975		1977	
		Cut	Fill	Cut	Fill
Ca	me/100g	3.7 a[2]	4.2 a	5.9 a	6.7 a
Mg	"	6.3 a	6.7 a	9.4 a	9.5 a
K	"	56.5 a	61.1 a	67.4 a	74.0 a
Na	"	7.0 a	6.6 a	2.9 a	2.9 a
N	"	-	-	25.7 a	22.5 a
P	"	3.7 a	5.0 b	3.2 a	5.6 b
Cl	"	27.2 a	35.1 b	39.4 a	43.2 a
EC	mmho/cm	8.0 a	9.0 b	10.2 a	11.2 a

[1] Values averaged over all N rates.

[2] Values in same row and year followed by same letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

Table 5. Effect of N fertilization on mineral content[1] of sugarcane juice.

Mineral constituents		Nitrogen applied-Kg/ha					
		0	112	224	0	112	224
			1975			1977	
Na	me/100g	7.2 a[2]	7.0 a	6.3 a	2.8 a	3.1 a	2.7 a
K	"	56.6 a	60.3 b	59.4 b	59.9 a	74.2 b	78.0 b
Ca	"	3.5 a	4.0 b	4.2 b	5.8 a	6.1 a	7.0 b
Mg	"	5.5 a	6.4 ab	7.7 b	8.0 a	9.5 ab	10.8 b
N	"	-	-	-	9.9 a	24.4 b	38.1 c
P	"	6.3 a	3.7 b	3.2 b	7.0 a	3.5 b	2.5 c
Cl	"	24.7 a	33.3 b	35.4 b	28.8 a	46.6 b	48.5 b
EC	mmho/cm	7.8 a	8.7 b	8.8 b	9.1 a	11.4 b	11.6 b
pH		5.5	5.4	5.4	-	-	-

[1] Values averaged for cut and fill areas.

[2] Values in same row and year followed by same letter are not significantly different at the 5% probability level according to Duncan's multiple range test.

Mineral Composition and Juice Quality

Nitrogen affected juice quality directly by increasing the N concentration of the juice and indirectly by increasing the concentration of cations and Cl. High concentrations of cations or EC were associated with low quality juice (Table 6). Apparently, the increased EC affected percentage pol more than brix (compare b values). The regression coefficients in the 2 years were not statistically different, and they indicated that a 1-mmho/cm increase in EC reduced pol, brix, and purity by 1.0, 0.7 and 2.3%, respectively. Because N fertilization changed the juice mineral concentration (except Na), highly significant correlation coefficients were found among the various elements and between the mineral constituents and percentage pol (Table 7). However, only a small part of the variation in pol was associated with Ca (36%), K (23%), and P (39%) as indicated by the coefficients of determination x 100. Results of a stepwise multiple regression analysis suggested that Mg and K together accounted for 91% of the variation in pol, whereas chloride, the main inorganic anion, accounted for 94% of the variation. Partial correlation coefficients between pol and N ($r_{YN.Cl}=-0.053$) and pol and P ($r_{YP.Cl}=0.028$) at a single Cl level were not significant. This suggested that the correlations between pol and N or P reflected the N-Cl and P-Cl relationships.

Table 6. Regression (b) and correlation (r) coefficients showing the relation between quality and electrical conductivity of sugarcane juice.

Quality component	1975		1977	
	b	r	b	r
%				
Pol	-1.05	-0.90**	-0.96	-0.94**
Brix	-0.68	-0.87**	-0.71	-0.92**
Purity	-2.66	-0.88**	-2.02	-0.92**

* Significant at P = 5%.
** Significant at P = 1%.

The relative importance of juice N and Cl concentrations to juice quality is shown in Fig. 1 and 2. Percentage brix and pol were only slightly affected at juice N concentrations greater than 20 me/100g, whereas percentage pol decreased progressively as juice Cl concentrations increased. High concentrations of Cl in the plant impede sugar production (2).

Table 7. Simple correlation matrix indicating the relationships among % pol and mineral constituents of the juice.

Item correlated	% Pol	Na	K	Ca	Mg	N	P	Cl
% Pol	-	ns	-0.479*	-0.598**	-0.791**	-0.819**	0.625**	-0.970**
Na		-	ns	ns	ns	ns	ns	ns
K			-	0.686**	0.900**	0.780**	-0.577*	0.534*
Ca				-	0.784**	0.600**	ns	0.631**
Mg					-	0.910**	-0.663**	0.820**
N						-	-0.832**	0.837**
P							-	-0.659**
Cl								-

ns not significant
* significant at p = 5%.
** significant at p = 1%.

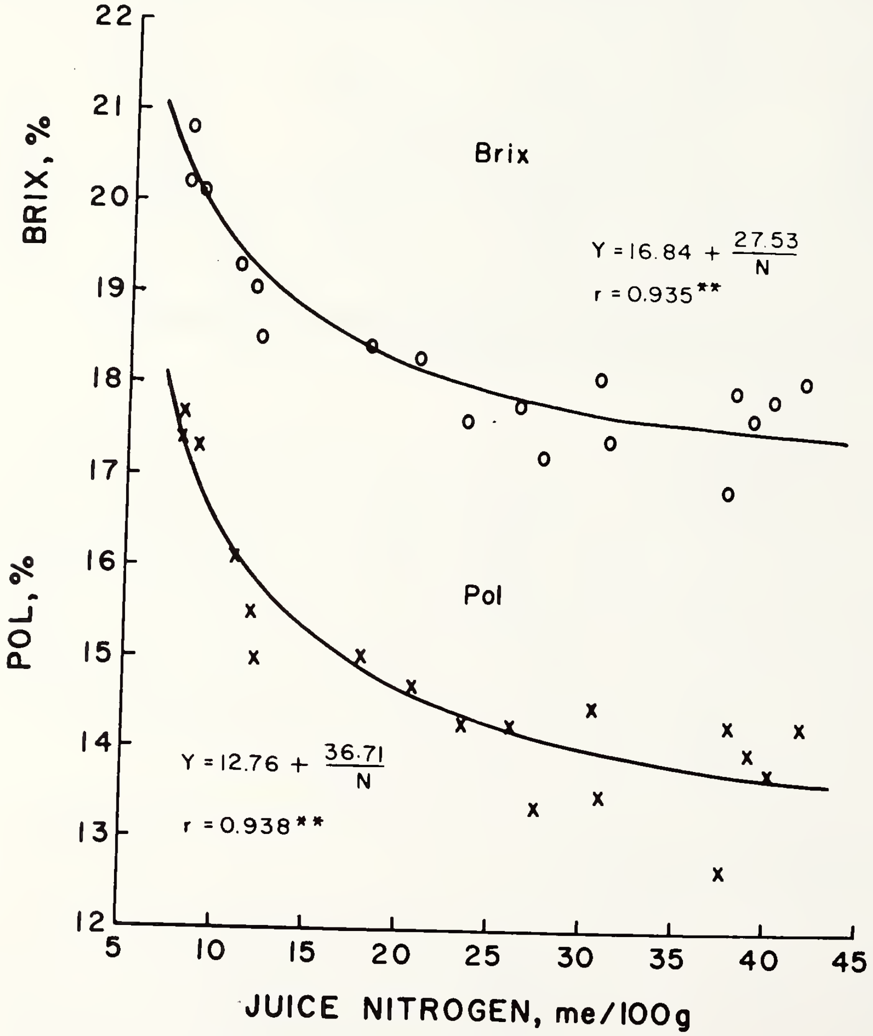


Fig. 1. Percentage brix and pol of sugarcane juice in relation to the juice N concentration.

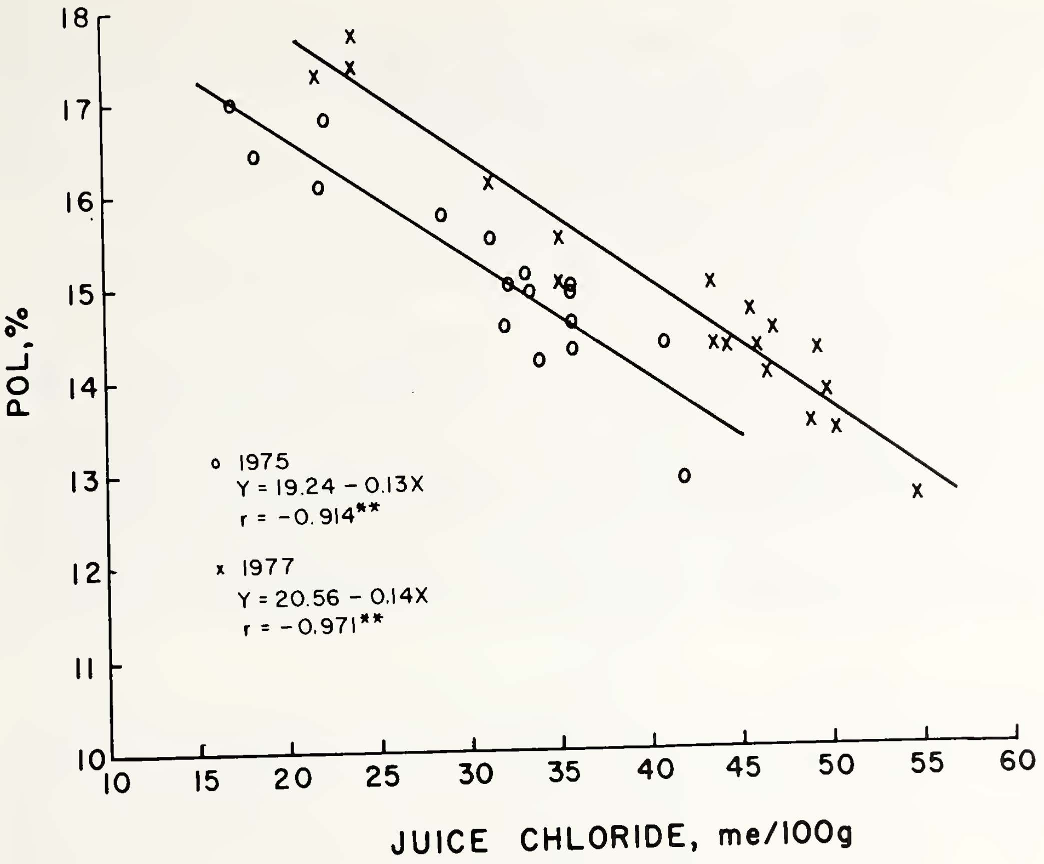


Fig. 2. Percentage pol of sugarcane juice in relation to the juice Cl concentration.

CONCLUSIONS

Poor juice quality (low pol and purity) was associated with large cane yields, high juice levels of cations, N and Cl, and low juice levels of P. Nitrogen fertilization affected juice quality chiefly by increasing the concentration of Mg, K, and Cl in the juice.

Since excess N decreased the sugar percentage, fertilizer N should be applied at rates to attain maximum cane yields per kilogram of N. The optimum N fertilizer rate cannot be determined from this study; however, the sharp yield increase between the 0- and 112-kg N/ha treatments suggested that the optimum fertilizer N rate was less than 112 kg/ha.

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COMPUTER ANALYSIS OF SUGARCANE DATA IN LOUISIANA

G. Dill, F. A. Martin, and K. L. Koonce
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana
and
C. A. Richard
American Sugarcane League

ABSTRACT

A computer program has been developed to facilitate calculation of sugarcane yield variables from observed data. This program has been designed to handle data collected by an array of sampling methods by using a predetermined sampling code specific for the research in question. Yield can be calculated from either observed variables such as stalk weight, juice polarity, etc. or calculated variables such as normal juice sucrose and sugar per ton. The estimation of sugar per ton and associated variables is also possible from data collected either by roller mill or press analysis. The program can also be used to handle other types of data (anatomical, morphological, physiological, etc.) so that the storage of all research data can be uniform. This program was developed utilizing SAS (Statistical Analysis Systems), a system for data management and statistical analysis. The advantage of a system of this type lies in the ease of handling large data sets for statistical analysis. Data collected over several years can also be kept easily accessible to the researcher for future reference and composit analysis.

INTRODUCTION

The system of data management to be described in this paper was developed with the intention of facilitating the calculation of sugarcane yield variables from observed data as well as the organization and statistical analyses of those data. The system has been structured in such a manner as not to require a vast knowledge of computer science or programming for its understanding and utilization. A major factor contributing to the simplicity of the system is its development in SAS (1, 2) (Statistical Analysis Systems). SAS itself is a network of programs which are registered in the computer requiring only simple commands to perform various mathematical operations and statistical analyses.

THE SYSTEM

A users guide for this particular system has been written outlining instructions for transposing observations onto data code sheets. Since most computer research centers have keypunching services, data need not be keypunched by the user, merely coded. This particular coding system is a multiple card system consisting first of an identification card followed by data cards containing actual observations.

The identification card is used in specifically defining the type of data which is to follow on succeeding cards. The first variable on the identification card is simply a card identification number. This card is designated by 0, and in a set of data cards is always the first card encountered. The next variable is research area which denotes the source of the data. For example, the numbers 0-9 designate the sugarcane breeding program at L.S.U. The research area is followed by year in which the research was conducted and the test identification number which corresponds to the researcher's own test identification code. Location is the next variable, and is stipulated by Mercador coordinates. This insures permanent identification of test location for future reference which is accomplished by simply entering N latitude and W longitude of the test location in question.

Type analysis is the next variable which designates the type of raw data to be entered into the program for the calculation of yield variables. This two digit variable actually controls the method by which yield variables are calculated from raw data. The type analysis variable is capable of computing yield variables such as tons of cane per acre and pounds of sugar per ton of cane from an array of sampling techniques and juice quality analyses, including press analysis. This allows the system to conform to the sampling and juice quality analysis techniques of the individual researcher, and leaves the method of yield variable calculation under his or her control.

The first digit in the type analysis variable controls the calculation of tons of cane per acre from either machine or hand cut samples. The second digit determines the calculation of pounds of sugar per ton of cane and related variables (i.e. poundsof sugar per acre) using the method described by Legendre and Henderson (3). This allows the calculation of yield variables from a number of sampling techniques and juice quality analyses by using the two digits in the type analysis variable in an array of combinations.

The next variable on the identification card designates experimental design, followed by plotsize, the Julien date of harvest and crop (plant cane, first stubble,....etc.). Finally, a word description of the test is written which can be used, along with other selected variables, as headings or titles on printed output.

The next type of card most commonly used is the yield data card. The first four variables on this and any other card are research area, year and specific test number used to match any card to its appropriate identification card. Harvest date, the next variable may also be entered on the yield card if several harvest dates are required within a particular test. Treatment date, heat treated progeny, percent mosaic, variety, replication, treatment and plot number are the next variables entered and are also used for identification purposes, as well as independent variables in sorting the data and statistical analyses.

The remaining variables are actually observations used in calculating yield variables. Temperature, observed brix, juice polarity, number of stalks per sample, bundle weight and stalk population, for instance, are used in calculating yield variable such as sugar per ton, pounds of sugar per acre, sucrose and purity from small plot research where plot sub-sampling is utilized. If whole plots are harvested and weighed, then plot weight, plot size and stalk population as well as temperature, observed brix and juice polarity are used in calculating the afore mentioned yield variables. Sugar per ton of cane can also be entered by the user in place of juice polarity if his or her method of juice quality analysis is already calculating this particular variable. In any case, yield variables will be calculated as specified by the type analysis variable selected by the researcher which corresponds to his or her sampling technique and juice quality analysis.

Calculation of yield variables using this system are also possible from data collected via press analysis. By entering the weight of the sample being analyzed, its weight after being pressed, and the dried weight of pressed samples, fiber determinations can be made along with the calculation of yield variables already mentioned. A flow diagram of the program is shown in Figure 1.

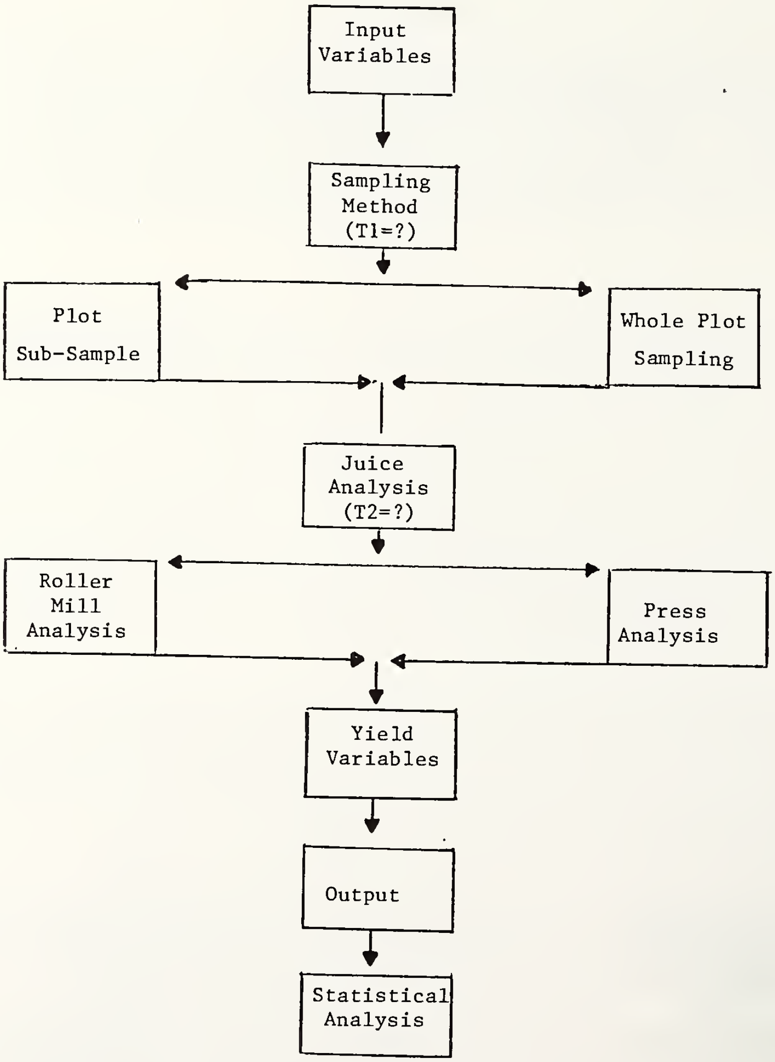

Figure 1. Flow diagram of the program

The development of this system of data management in SAS affords several avenues of data storage, management and analysis. Observations may be stored on disk or magnetic tape, as well as on computer cards. Printed output can be bound for use as a convenient and systematic reference to data which has been logged into the system. For these purposes, data listings, means and other methods of data display including graphic illustration are available. As might be expected, analysis of data in this particular system is rapidly performed within SAS. Analysis of variance, specific treatment comparisons and many other statistical analysis are made available within the SAS system making the analyses of large data sets, and the analysis of interdisciplinary research data more practical.

In conclusion, this system is capable of a time savings in the handling of research data while providing a systematic and uniform method of data management. The system is capable of accomodating data from many different disciplines of sugarcane research. It also allows the tedious calculation of yield variables such as sugar per ton of cane and tons of cane per acre from an array of sampling and juice analysis techniques. Probably the greatest benefit of a system of this type is its capacity for the organization of large amounts of research data into an orderly system of data handling, while affording the convenience of an array of statistical analyses without a vast knowledge of computer science or programming.

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THE PEDIGREE OF SELECTED CANAL POINT (CP) VARIETIES OF SUGARCANE

Peter Tai and J. D. Miller
U.S. Sugarcane Field Station
SEA, USDA
Canal Point, Florida 33438

ABSTRACT

The pedigrees of 17 CP varieties of sugarcane released for commercial production or developed as breeding lines during the last two decades were documented. We hope this pedigree information will provide effective reference of historical interest concerning the parentage of CP commercial and breeding canes. Also, it will provide information for planning breeding programs for future CP varieties. The ancestry of all varieties traced back to 3 species: Saccharum officinarum, S. spontaneum, and S. barberi. A fourth species, S. sinense, was transmitted in the pedigree of 7 CP varieties. The major contributor of genetic factors was S. officinarum with S. barberi the second most important contributor.

INTRODUCTION

The U. S. Department of Agriculture established a sugarcane experiment station on Collins Key (now Miami Beach) in 1918, but moved the operation to Canal Point in 1920 (1, 7, 10). The initial objective was to develop varieties resistant to mosaic disease, root rot, and red rot for planting in Louisiana. True seeds were produced at Canal Point and sent to Louisiana for selection. The breeding work at Canal Point has increased in volume and in scope since the expansion of the Florida sugar industry in the early 1960's (10). A three-way agreement between the Florida Sugar Cane League, Inc., the University of Florida, and the U. S. Department of Agriculture provides for testing, increasing and distributing new varieties to the sugarcane growers of Florida (7, 10). In addition to the variety development program, this station continues to produce true seeds for the sugarcane variety development programs in Louisiana and Mississippi. A large crossing house built in 1959 has made possible the production of large quantities of seed.

Historically, CP 807 was the first Canal Point variety produced from seed at this station to reach commercial production in Louisiana and CP 34-79 was the first Canal Point variety to attain commercial importance in Florida (10). Pedigrees of 28 Canal Point varieties released for commercial culture during the period 1930 to 1960 were reviewed by Stokes and Tysdal (24). They reported that the basic genetic factors of those varieties came from 10 clones used as parents in 11 initial crosses.

The objective of this paper is to present the ancestry of 17 Canal Point varieties released for commercial production or used as breeding lines during the last two decades (2, 3, 6, 8, 9, 11, 15, 19 to 23). Two varieties, CP 50-28 (18) and CP 52-68, reviewed by Stokes and Tysdal (22), are also included in this paper. The parentage of these 17 CP varieties and their dates of release are listed in Table 1. Thirteen of the 17 varieties were registered with Crop Science Society of America.

Table 1. Parentage and date of release of 17 CP varieties of sugarcane.

Variety	Parentage	Releasing agency	Date of release
CP 50-28	CP 43-64 x CP 33-372	USDA, FAES[1]	1957
CP 52-68	CP 29-320 x CP 38-34	USDA	1958
CP 56-59	Cl 47-83 x CP 34-79	USDA, FAES, FSCL	1967
CP 56-63	Cl 47-83 x CP 36-105	USDA, FAES, FSCL	1968
CP 57-120	CP 43-74 x B 45181	USDA	Breeding line
CP 57-526	CP 52-114 x US 54-24-9	USDA	Breeding line
CP 57-603	Cl 47-143 x ?	USDA, FAES, FSCL	1967
CP 57-614	Cl 47-183 x CP 53-17	USDA, FAES, FSCL	1968
CP 59-50	CP 44-155 x CP 52-34	USDA	Breeding line
CP 59-73	F 36-819 x CP 33-372	USDA, FAES, FSCL	1967
CP 62-374	CP 53-18 x CP 33-324	USDA, FAES, FSCL	1969
CP 63-306	CP 50-28 x CP 52-15	USDA, FAES, FSCL	1971
CP 63-588	Cl 54-1910 x CP 57-120	USDA, FAES, FSCL	1968
CP 65-357	CP 52-68 x CP 53-17	USDA, LAES, ASCL	1973
CP 68-1026	Cl 47-83 x CP 57-614	USDA, FAES, FSCL	1975
CP 68-1067	CP 52-68 x CP 57-603	USDA, FAES, FSCL	1975
CP 70-1133	67 P 6s x CP 56-63	USDA, FAES, FSCL	1977

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[1] USDA = U.S. Department of Agriculture; FAES = Florida Agricultural Experiment Station; FSCL = Florida Sugar Cane League, Inc.; LAES = Louisiana Agricultural Experiment Station; ASCL = American Sugar Cane League of the U.S.A., Inc.

The two most widely grown varieties in Florida are CP 63-588 and CP 56-59 (38% and 13.5% of the sugarcane acreage, respectively) according to the latest variety census (12). CP 62-374 was grown on approximately 3.3% and CP 57-603 on 1.7% of the acreage for the 1977-78 crop. CP 57-603 is a late-maturing variety planted on 1.4 to 3.5% of the state sugarcane acreage since its release in 1967. The rest of the CP varieties were planted on less than 1% of the acreage or are no longer in commercial production. CP 63-588 has a high sugar content and good milling qualities and achieved second place in total acreage in Florida in 1971 and first place in 1975. Among other CP varieties to achieve second place in total acreage were CP 50-28 (10), CP 56-59 and CP 57-603 (10, 12). Varieties CP 57-120, CP 57-526 and CP 59-50 were used as parents in the variety development program. CP 65-357, which was produced from a cross made at Canal Point, was developed through cooperative research of the U.S. Department of Agriculture, the Louisiana Agricultural Experiment Station, and the American Sugar Cane League of the U.S.A., Inc. and was released to the Louisiana industry in 1973. CP 65-357 is presently the principal variety in Louisiana (13) and its acreage is increasing in Florida.

Most varieties of sugarcane (bred at experiment stations) are designated by a combination of letters and numbers that indicate the place or institution where they originated and the date of selection. The abbreviations used in Fig. 1 are summarized in Table 2.

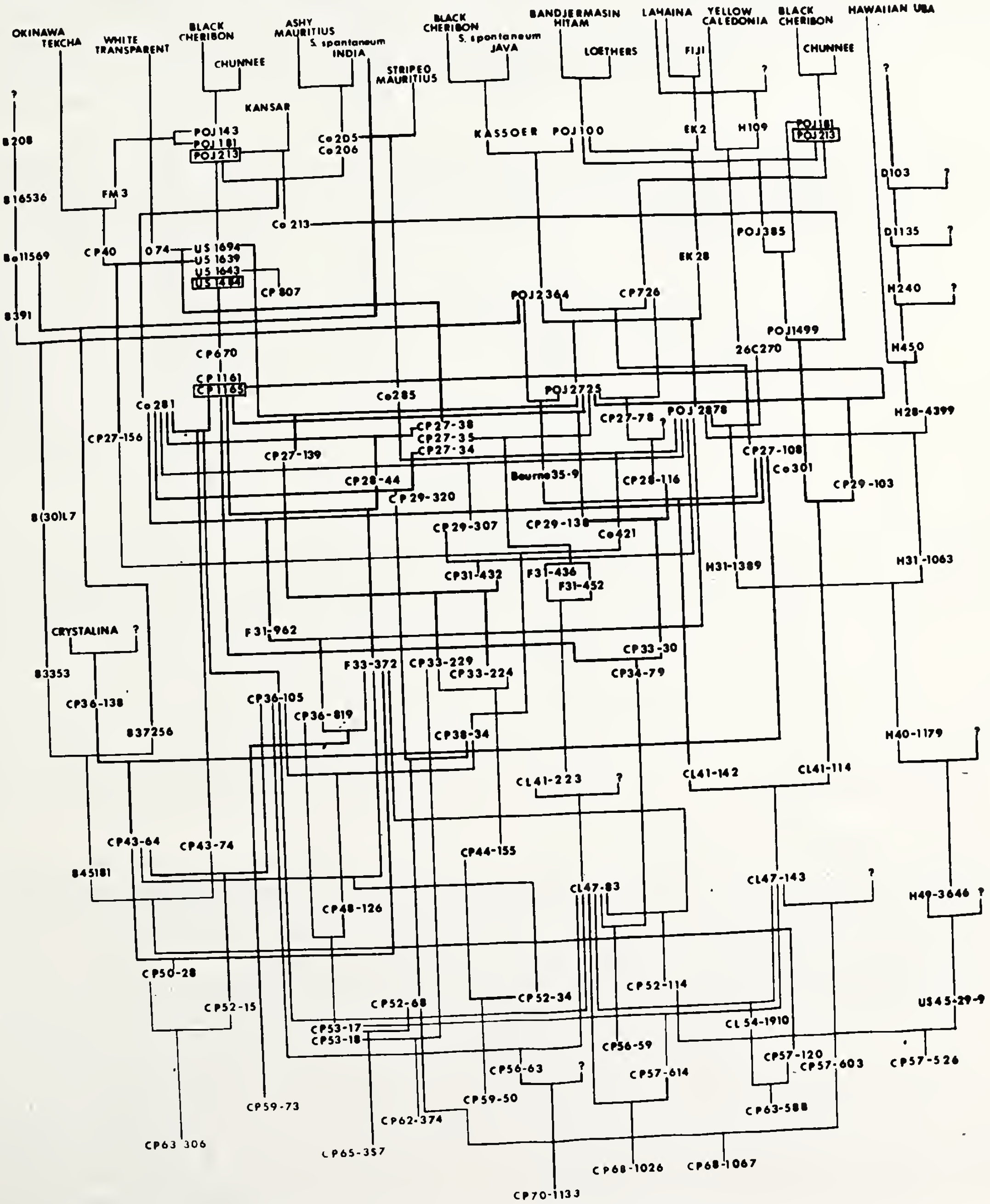

Fig. 1. Pedigrees of CP (Canal Point) and certain other varieties of sugarcane.

Table 2. Abbreviations used to designate the origin of sugarcane clone.

B	Barbados
Ba	Barbados selfs
CP	Canal Point, Florida
Cl	Clewiston, Florida
Co	Coimbatore, India
26 C 270	1926 (Yellow) Caledonia Selection 270 (H.S.P.A.)
D	Demerara (British Guiana)
EK	Seedlings raised by Edward Karthaus, Java
F	Florida
FM	Formosa Male Selection
H	Hawaii
L	Louisiana
NG	New Guinea
POJ	Proefstation Oost Java (East Java Experiment Station)
US	US Department of Agriculture Sugarcane Breeding Station at Canal Point, Florida

Grassl (4) indicated that the binomials, Saccharum edule Hassk, S. sinense Roxb. and S. barberi Jeswiet were not valid species because of their generic hybrid nature. He suggested that the genus Saccharum consists of only 4 species: S. officinarum L., S. robustum Brandes & Jeswiet exGrassl, S. spontaneum L. and S. sanguineum (Grassl) Grassl. He also suggested that the 3 invalid species can be referred to as horticultural groups (collective hybrid epithets) such as the Edule, the Sinense, and the Barberi just as we refer to the S. officinarum cultivars as the Noble group. For convenience in regard to the materials and references, the binomials S. sinense and S. barberi are used in this article.

The pedigrees of the 17 CP varieties in this study show the complexity of the genetic background of these sugarcane varieties. Their basic genetic factors came from 16 known clones plus several unknown parents. Among the 16 clones, ten were S. officinarum, two S. sinense (Hawaiian Uba and Okinawa Tekcha), two S. spontaneum (Indian and Java forms) and two S. barberi (Chunnee and Kansar). Frequency of the four species S. officinarum, S. spontaneum, S. sinense, and S. barberi indicates the predominance of S. officinarum in the background of these varieties (Table 3). Genetic factors from various species of Saccharum were transmitted through the initial crosses of 18 first-generation hybrids. The ancestry of all varieties traced back to 3 species: S. officinarum, S. spontaneum and S. barberi. Also two forms of S. spontaneum entered the pedigree of all varieties except CP 56-59 and CP 57-603, which only had the Java form of S. spontaneum. S. spontaneum was transmitted in the pedigrees through POJ 2364 (the first-generation hybrid of Kassoer or the second generation hybrid of the Java form of S. spontaneum) and through either Co 205 or Co 206 an Indian form of S. spontaneum was transmitted in the pedigrees. S. sinense has produced a few of its derivatives that have yielded useful CP varieties. The CP 57-526 variety received its S. sinense germ plasm from Hawaiian Uba whereas six other varieties, CP 52-68, CP 57-614, CP 62-374, CP 65-357, CP 68-1026, and CP 68-1067 had S. sinense in their ancestry transmitted through CP 40. The S. barberi was transmitted to the CP varieties through POJ 143, POJ 181, POJ 213 or Co 213. The POJ varieties were from crosses between Chunnee, of the Saretha group of S. barberi, and the noble cane Black Cheribon. POJ 213 was backcrossed to another Saretha variety, Kansar, to produce Co 213. Table 3 is the summary of the frequency of transmissions of each species in pedigrees of the CP varieties. The frequency of transmission is expressed as the number of paths which connect CP varieties and the various clones of Saccharum species. The higher the frequency and the more the species involved, the more complex the varieties will be. If only the known Saccharum clones are considered, CP 62-374 and CP 68-1026 are the most complex varieties among the varieties studied. CP 63-588, CP 65-357 and CP 68-1067 are the next most complex varieties.

Table 3. The frequency of transmission of Saccharum genetic factors in the pedigrees of 17 CP varieties.

Variety	S. officinarum	S. barberi	S. spontaneum Java	S. spontaneum India	S. Sinense
CP 50-28	9	4	1	1	-
CP 52-68	15	4	1	2	1*
CP 56-59	20	4	3	-	-
CP 56-63	10	3	1	1	-
CP 57-120	8	2	1	2	-
CP 57-526	26	4	3	1	1**
CP 57-603	19	5	3	-	-
CP 57-614	50	10	7	3	1*
CP 59-50	33	6	4	2	-
CP 59-73	16	5	1	2	-
CP 62-374	44	6	6	4	1*
CP 63-306	11	5	1	2	-
CP 63-588	38	8	4	3	-
CP 65-357	24	9	2	4	2*
CP 68-1026	46	8	6	4	1*
CP 68-1067	31	7	4	2	1*
CP 70-1133	10	3	1	1	-

*Okinawa Tekcha; **Hawaiian Uba

The frequency of transmissions of each species do not indicate the relative amount of genetic factors that have been transmitted in the pedigree of each variety. The theoretical percentage of genetic factors from Saccharum was calculated from the assumption that it reduced one-half (1/2) of its genetic factors from one generation to the next (14). The major contributor of genetic factors was S. officinarum (an average of 52.5%) with S. barberi the second most important contributor (an average of 19.0%). However, the genetic factors from unknown parents were very high (an average of 28.6%) among those 11 varieties originated from an open-cross *per se* or polycrosses (Table 4). It, however, should be remembered that a chromosome increase accompanies certain crosses and backcrosses and modern varieties have very high aneuploid chromosome numbers and complicated genetics (16, 17). Furthermore, chromosome counts are not available for most of the CP varieties and their parents. Chromosome transmission in inter- and intra-specific crosses involving Saccharum would certainly complicate the transmission of the genetic factors of these varieties.

Table 4. The theoretical percentage (%) of transmission of Saccharum genetic factors in the pedigrees of 17 CP varieties.

Variety	S. officinarum	S. barberi	S. spontaneum Java	S. spontaneum India	S. sinense	Unknown
CP 50-28	56.2	25.0	3.1	3.1	-	12.6
CP 52-68	60.9	21.9	1.6	9.4	6.2*	-
CP 56-59+	45.7	20.3	2.7	-	-	31.3
CP 56-63+	45.3	21.9	1.6	6.2	-	25.0
CP 57-120	59.4	18.8	15.6	6.2	-	-
CP 57-526+	32.2	10.9	1.6	1.6	1.6**	52.1
CP 57-603+	33.6	13.2	3.1	-	-	50.0
CP 57-614+	65.2	23.3	5.9	3.9	1.6*	-
CP 59-50	64.8	20.3	5.5	3.1	-	6.2
CP 59-73	64.1	25.0	4.7	6.2	-	-
CP 62-374+	68.4	18.0	6.6	5.5	1.5*	-
CP 63-306	54.7	25.0	3.1	4.7	-	12.5
CP 63-588+	56.6	17.6	10.2	3.1	-	12.5
CP 65-357	62.1	21.1	3.5	8.6	4.7*	-
CP 68-1026+	52.7	14.8	4.5	2.0	0.8*	25.0
CP 68-1067+	48.1	16.0	2.3	5.5	3.1*	25.0
CP 70-1133+	22.8	10.9	0.8	3.1	-	62.5
Average	52.5	19.0	4.5	(4.8)	(2.2)	(28.6)

* Okinawa Tekcha; ** Hawaiian Uba
+ Originated from an open-cross *per se* or through ancestral parents.

No known S. robustum clones are contained in the pedigrees of these 17 CP varieties. This species was used extensively in the crossing program at Canal Point station in the middle 1930's. Grassl (personal communication) has long considered CP 36-138 (Crystalina X 28 NG 251) as something other than S. officinarum X S. robustum. Price (16) found CP 36-138 has chromosomes 2n = 112. However, Crystalina (2n = 80) X 28 NG 251 (2n = 80) would probably produce a hybrid with 2n = 80 rather than 2n = 112. The chromosome count confirmed suspicions suggested by morphological observations.

Among CP 29-116, CP 36-105 and CP 44-101, which were mentioned by Stokes and Tysdal (24) as the most extensively used CP varieties in Louisiana, only CP 36-105 was used as a parent in the development of new CP varieties for Florida including CP 56-63, CP 65-357 and CP 70-1133. CP 56-63 was never an important variety. CP 65-357, which was released in Louisiana in 1973, is gaining in acreage in both Louisiana and Florida because of its high yield, good stubbling ability and moderate cold tolerance. CP 70-1133 was released in 1977; therefore, it is still too early to judge the potentiality of the variety.

A survey of the pedigree chart (Fig. 1) shows that parents in the early stage of breeding work at Canal Point were predominantly from two major sources, POJ varieties from Java and Co varieties from India. As new CP varieties became available, they were used as parents in crosses with POJ and Co varieties or with themselves. For the next phase, CP and Cl varieties (Clewiston) were used extensively as parents to develop new CP varieties. Barbados and Hawaiian varieties also were used as parental materials on a limited basis. One of the most important CP varieties, CP 63-588, had Barbados germ plasm (B 45181) in the pedigree. The chart also reveals that CP 1165 is an outstanding variety based on the number of times it appears in the pedigrees of these varieties.

Stokes and Tysdal (24) found that only a few clones were prominent in the parentages of the 28 CP varieties and questioned whether progress in the breeding program might be limited by the small amount of divergent germ plasm. The present review indicates that concern about a narrow genetic base still exists and that some of the new varieties have reached high levels of inbreeding (Fig. 1 and Table 4). The current breeding program is emphasizing the utilization of wild relatives of sugarcane. Several different clones of S. spontaneum have been used as parents in the cold tolerance breeding program. This program is expected to broaden the genetic base of future CP breeding lines and be the foundation for another major advance in productivity and adaptability in the next two decades.

Intergeneric crosses are also being made by C. O. Grassl (personal communication) to enlarge the genetic base of future parental clones and to possibly add useful genes to the genus *Saccharum*. He has used wild relatives of *Saccharum* which include *Miscanthus*, *Ripidium*, and *Sclerostachya*, to produce hybrids between cultivated canes and wild relatives. These hybrids cannot be directly used in the nobilization program because they are sterile (5,6); however, colchicine treatments are being used to double chromosome numbers in an attempt to overcome this barrier.

SUMMARY

The pedigrees of 17 CP varieties of sugarcane released for commercial production or used as breeding lines during the last two decades are presented. Of those 17 varieties, thirteen were registered with the Crop Science Society of America. The ancestry of all varieties traced back to 3 species: *Saccharum officinarum*, *S. spontaneum* and *S. barberi*. Only two forms of *S. spontaneum* entered the pedigree of all varieties except CP 56-59 and CP 57-603, which only had the Java form of *S. spontaneum*. A Java form of *S. spontaneum* was transmitted in the pedigrees through POJ 2364 and an Indian form of *S. spontaneum* was transmitted in the pedigrees through either Co 205 and Co 206. The CP 57-526 variety received its *S. sinense* blood from Hawaiian Uba whereas six other varieties, CP 52-68, CP 57-614, CP 62-374, CP65-357, CP 68-1026 and CP 68-1067 had *S. sinense* in their ancestry transmitted in the pedigree through CP 40. The *S. barberi* was transmitted to the CP varieties through POJ 143, POJ 181, POJ 213 or Co 213. The major contributor of genetic factors was *S. officinarum* with *S. barberi* the next most important contributor. No known *S. robustum* clones are contained in the pedigrees of these varieties. Eleven of the 17 varieties contained an open-cross *per se* or a polycross in their ancestry where the male parent was unknown; therefore, portions of the pedigrees remain unknown.

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FIELD PLANTING OF SHORT SUGARCANE SEED PIECES IN LOUISIANA [1]

G. T. A. Benda, H. P. Fanguy, J. E. Irvine, and R. D. Breaux
U.S. Sugarcane Field Laboratory
Agricultural Research, Science & Education Administration, USDA
Houma, Louisiana 70361

ABSTRACT

Commerical fields in Louisiana are routinely planted with whole stalk seed cane. The seed cane is mechanically cut with soldier-type harvesters, mechanically loaded into wagons, and then distributed to the furrow, either manually or mechanically. Mechanical planters have not been completely accepted because of the difficulty growers have in obtaining a uniform distribution of seed cane in the furrow and in planting crooked seed cane. These problems may be avoided with short seed pieces, but it is widely believed that plantings of short seed pieces would not survive the Louisiana winter. Based on five experiments involving five varieties and plantings in five months of four years, our results indicate that short seed pieces (11 to 20 inches long) can produce a plant-cane crop comparable in yield to that from whole stalks (5 to 6 ft long) planted at comparable rates, provided the seed pieces were either hand cut or cut by an Australian planter. Cane planted using short seed pieces (9 to 14 inches ave. length) cut by a combine harvester does not yield as well as cane planted using whole stalks, apparently because of damage done to the seed piece by the harvester.

INTRODUCTION

The advantage of whole-stalk planting in a temperate region is linked to increased survival during the winter and increased growth during the spring. Seed cane, especially when planted later in the year, lies dormant under conditions that permit the growth of pathogens. The many nodes and internodes present in whole stalks provide the maximum number of intact nodal plates to hinder the spread of infections and the minimum number of wounds to serve as foci of new infections. The stored food available from intact internodes hastens the development of young shoots under favorable conditions and favors the development of tillers.

Commercial sugarcane fields in Louisiana are planted with whole stalks, whereas those in the more tropical regions are planted with seed pieces shorter than one-fourth of a stalk. Experimental results obtained years ago (2,4) indicated that, due to increased survival during Louisiana winters, experimental plots planted with whole stalks or whole stalks cut in half often yield better than plots planted with shorter seed pieces.

Whole-stalk planting has disadvantages related to the difficulty encountered in mechanizing the planting operation and in the quantity of seed cane required. Whole stalks with leaves attached tend to mat, a situation which frequently causes mechanical planters, especially when the stalks are crooked, to pull out a bundle of stalks when a few are needed; seed pieces cut shorter than one-fourth of a stalk generally separate readily, even when cut from crooked stalks.

The quantity of seed cane required in Louisiana limits planting during July and early August when planting ratios (the area planted to the area of seed cane harvested) may be 4 or less. The results with 6-inch seed pieces (3) indicated that a four-fold increase in planting ratio was possible; however, subsequent results (unpublished) have shown that such short seed pieces give unreliable results unless irrigation is available.

This paper reports the results of experiments in which the yield from seed pieces (11 to 20 inches long) and whole-stalk seed cane is compared. The availability of combine harvesters in recent years has provided a machine that can prepare seed pieces mechanically, and the billets from these machines were tested as well as hand-cut seed pieces.

MATERIALS AND METHODS

Sugarcane stalks of five varieties (CP 48-103, CP 52-68, CP 61-37, CP 65-357 and L 62-96) were used as planting material. All seed cane was field grown. Seed cane was harvested by hand, by soldier-type harvesters, or by combine harvester (Toft Robot 300, Cameco 1000 experimental model, and Massey Ferguson Model

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[1] A contribution from AR, SEA, USDA in cooperation with the Louisiana Agricultural Station.

102[2/]). Seed pieces were prepared by the combine harvesters, by the Don Planter, or by a hand-operated hinged knife blade (hand-cut seed pieces). Unless otherwise noted, all seed cane and seed pieces were used without selection except that seed pieces predominantly of leaf spindle tissue (tops) were rejected. Neither the seed pieces nor the seed cane were cleaned of leafy material.

All experiments were planted at or near the U.S. Sugarcane Field Laboratory, Houma, Louisiana. The cane was planted according to the standard Louisiana system on ridged rows 6 feet apart. The plots were 16 to 80 feet long (including walkways) per row and 1 to 3 rows (6 to 18 ft) wide. The rows were opened with a V-shaped opening plow. The seed pieces were placed in the furrow either by the Don Planter or by hand so as to lie end-to-end or to include gaps; the whole stalks were placed by hand to lie end-to-end without gaps or overlap. The planting rate is defined as being equal to the number of running stalks planted side-by-side or equivalent cane in seed pieces planted end-to-end and side-by-side. The planted cane was covered with a disc cultivator or a specially designed controlled-depth (CoDe) covering tool consisting of a depth wheel and a V-shaped sweep used in conjunction with a disc cultivator (Fig. 1). The soil was not packed after covering.

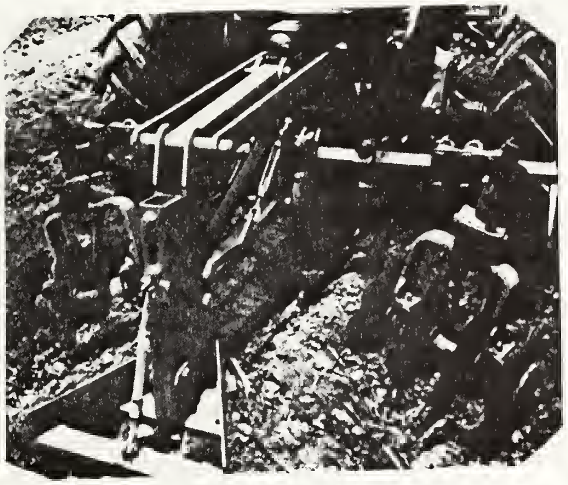

Fig. 1. Controlled-depth (CoDe) covering tool to adjust the thickness of the soil layer over newly planted sugarcane. The depth wheel which runs over the dropped cane in the furrow regulates the level of an adjustable V-shaped sweep that removes excess soil thrown by the discs.

Cultural practices, cultivation and application of fertilizer, herbicide and insecticide followed the recommendations for plantation practice (8) during the growing season of the following year. The practices included the building up of the row regardless of the depth of cover after planting.

Millable stalks were counted in late August or early September.

The cane was harvested in November or early December by cutting top and bottom. Experiment 1 was harvested by soldier harvester, the other experiments were harvested by hand. In Experiments 1 and 4, the cane was burned on the "heap row" to remove the trash. In Experiments 1, 2, and 4, the cut cane of each plot was weighed in the field. In two experiments (Experiments 3 and 5), the yields were estimated from the millable stalk number and from the average stalk weight of the 15-stalk sample.

In all experiments, samples of 15 stalks were taken from each plot, weighed and crushed once through a 3-roller sample mill. The juice was analyzed to determine apparent sucrose (6,9).

The results were analyzed using the method appropriate to the experimental design (complete randomized blocks, simple factorial, split plot, or split-split plot). The number of replications of each treatment varied from 4 to 6 among experiments.

[1/] Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

EXPERIMENTAL PROCEDURES AND RESULTS

Information on variety and on planting and harvesting dates is included in the tables that record the results of each experiment. Experimental details and results specific to each experiment follow:

Experiment 1

Procedure: In this factorial experiment, there were three dates of planting (July, August, October), three varieties (CP 61-37, CP 65-357, L 62-96), and three rates of planting (planting rate equals 2 for whole stalks and equals 1 or 1/2 for 13-inch seed pieces). Plot size was 24 x 18 ft, and there were four replications.

The seed cane for this experiment was hand-cut from stubble fields: first stubble for CP 65-357 and third stubble for CP 61-37 and L 62-96. The average stalk length for the July planting ranged from 2.2 to 3.8 ft, depending on variety.

The repeated planting within the same field posed special problems of weed control. After the July planting, the entire field was treated with terbacil (0.6 lb/acre); after the August planting, the newly planted plots were treated with simazine (1 lb/acre). The weed population became very heavy, especially between the rows, and it was necessary to cultivate before the October planting. No herbicide was applied following this planting.

Results: The yield of sugar per acre is shown in Table 1. When the average yields from plots planted with whole stalks are compared with those from plots planted with 13-inch pieces of the same variety and planting date, only two of the nine comparisons are significantly different despite the differences in planting rate. The plots planted with 13-inch seed pieces at 1 running stalk of CP 65-357 in August and October yielded significantly less than the plots planted with whole stalks at 2 running stalks.

Differences in yield of sugar per ton of cane within a variety generally were not significant regardless of planting date and seed piece size or planting rate. The yield from plots planted with 13-inch seed pieces of CP 61-37 in October is the single exception; these yielded significantly less sugar per ton of cane than the other plots planted with CP 61-37 (data not shown).

Experiment 2

Procedure: In this split-plot experiment, the main effect was variation in the depth of soil cover after planting (2 to 5 inches) and the subplot treatments involved seed preparation (whole stalks, hand-cut seed pieces 11 inches in length, combine-cut seed pieces). The planting rate was constant and equal to 3. The subplot size was 22 x 18 ft, and there were 6 replications.

The seed cane of variety CP 61-37 was harvested at the Louisiana State Experiment Station, St. Gabriel. The billets from a Toft Robot 300 combine harvester were used as the combine-cut seed pieces. Cane harvested by a soldier-type harvester was used for whole stalks and hand-cut seed pieces.

The average length of the combine-cut seed pieces was 9 inches for a representative sample of 231 pieces; they ranged from 2 to 19 inches in length, with an average node number of 1.7 per seed piece. When 67 seed pieces less than 6 inches in length were disregarded, the other 164 seed pieces averaged 11 inches in length. When planted, both seed cane and seed pieces were used without selection.

After planting, the depth of soil over the cane was adjusted to either 2 or 5 inches with a CoDe covering tool. No more soil was added during the severe winter which followed; there were repeated low temperatures and a minimum air temperature of 19° F.

The experiment was hand-harvested. The cane was weighed and sampled without burning, and no correction for trash (average 18.2%) was made.

Results: When total shoots were counted on April 28, 1977, the main plots covered to a depth of 5 inches had significantly fewer shoots than those covered to a depth of 2 inches, and the subplots planted with combine-cut seed cane had significantly fewer shoots than those planted with whole stalks and with hand-cut seed pieces. The average number of shoots, in thousands per acre, for whole stalks, hand-cut seed pieces and combine-cut seed pieces were calculated to be 18.6, 19.0 and 8.7, respectively, for the 2-inch cover, and 12.9, 12.6 and 6.0, respectively, for the 5-inch cover.

When the cane was weighed after harvest, the results showed that neither the difference in main plots between the 2-inch and 5-inch cover nor the interaction cover x seed preparation was significant. The results for seed preparation were highly significant (Table 2), with reduced yield in plots planted with combine-cut seed pieces--both in tons per acre and sugar per acre. The yields from plots planted with whole stalks and hand-cut 11-inch seed pieces did not differ significantly.

Table 1. Yield of sugar (lbs/acre) as a function of date of planting, variety, seed preparation and planting rate (Experiment 1)[1].

Cane planted as	Planting rate	Date of planting 1973								
		July 24			August 20			October 18		
		CP 61-37	CP65-357	L 62-96	CP 61-37	CP 65-357	L 62-96	CP 61-37	CP 65-357	L 62-96
Whole stalk	2	5715 cd[2]	7400 b	5032 cf	6753 bc	9022 a	5065 cf	5697 ce	6767 bc	2757 hi
Seed piece (Hand-cut 13 in.)	1	5242 cf	6565 bc	4560 dg	5274 cf	6195 bd	4396 eh	4193 eh	3158 gi	1880 i
Seed piece (Hand-cut 13 in.)	1/2	5059 cf	5456 ce	3638 fh	5534 ce	5203 cf	2882 gi	4363 eh	3133 gi	1633 i

[1] Harvested on December 4, 1974.

[2] Means followed by the same letter or letters in rows and columns are not significantly different at the 5% level of probability; only the first and last letter of the alphabetical sequence are shown when more than two letters follow a mean.

Table 2. Comparison of yield from cane (CP 61-37) planted as whole stalks and as seed pieces prepared by hand or combine harvester (Experiment 2[1].

Cane planted as	Planting rate	Cane (t/a)	Sugar in cane (lb/t)	Sugar (lb/a)
Whole stalk	3	29.7 a[2]	218 a	6455 a
Seed piece				
Hand-cut (11 in.)	3	29.8 a	218 a	6502 a
Combine-cut (ave. 9 in.)	3	22.2 b	214 a	4762 b

[1] Planted September 1, 1976; Harvested December 14, 1977.

[2] Column means followed by the same letter are not significantly different at the 5% level of probability.

The yield of sugar per ton of cane (Table 2) did not differ significantly for depth of cover, seed preparation, or their interaction. There were also no significant differences in average stalk weight as determined from the weight of 15-stalk samples (data not shown) among seed preparations.

Experiment 3

Procedure: The design of this experiment was that of a split-split plot in which the blocks were the depth of soil after planting (about 2 or 5 inches), the plots either had soil added to the drill before winter or not, and the subplots were planted with whole stalks, with combine-cut seed pieces, or with seed pieces hand-cut to be 7, 12.7, or 19.6 inches in length; the hand-cut seed pieces will be referred to as 7, 13, or 20 inches, respectively. The variety used was CP 48-103. The plot size was 20 x 18 ft and there were 5 replications. All plots were hand-planted at a planting rate equal to 2.

Cane for this experiment was harvested at Greenwood Plantation, Southdown Corporation, Thibodaux, either by means of an experimental model of a combine harvester (Cane Machinery and Engineering Co., Thibodaux, La.) or by a commercial soldier-type harvester. The billets from the combine harvester were used as combine-cut seed pieces without selection. The 6-ft stalks cut by the soldier-type harvester were used as whole stalks or for hand-cut seed pieces.

The experimental combine harvester produced seed pieces with a mean length of 14 inches and a range from less than 2 to 24 inches; the average number of buds per seed piece was 1.66.

The depth of soil cover following planting was adjusted either with a disc cultivator to give an approximate 5 inch cover, or with a disc cultivator and CoDe covering tool to give a cover of 1 or 2 inches following planting. Half of the latter plots had about 2 inches of loose soil added December 5, 1974, with a disc cultivator.

Millable stalks in all plots were counted August 29, 1975, and 15-stalk samples for stalk weight and sugar content were taken from each plot after hand-harvesting on November 13. Yield of cane and sugar per acre were estimated from the millable stalk number and from the average stalk weight and sucrose content of the 15-stalk sample.

Results: In the analysis of the results, the addition of soil in December had no significant effect either on yield or interaction. The winter of 1974-75 had been mild, with a minimum air temperature of 26° F; it is not known whether the mild winter was responsible for this result.

The experiment was re-analyzed as a split-plot design with 10 replications. The interaction, depth of cover x seed size, was not significant for yield in terms of cane per acre, sugar per ton, or sugar per acre.

Estimated yields of cane per acre and sugar per acre were significantly higher for the lightly covered cane than for the more deeply covered cane. The average value for the 50 subplots of the more lightly covered cane was 28.5 tons per acre and 7073 lbs sugar/acre, while the more deeply covered cane averaged 26.7 tons and 6485 lbs, respectively. The differences in sugar/ton cane were not significant.

The estimated yield for plots planted with whole stalks and seed pieces is shown in Table 3. Plots planted with combine-cut seed pieces yielded significantly less than those with hand-cut seed pieces or whole stalks in cane per acre, sugar per ton, and sugar per acre. In terms of tons cane/acre, the plots planted with hand-cut seed pieces and whole stalks were not significantly different. Plots planted with the shortest hand-cut seed pieces (7 inch) had significantly less sugar per ton of cane than whole stalks, but the differences in sugar per ton among plots planted with hand-cut seed pieces (7, 13 and 20 inches) were not significant. The highest yields in sugar per acre were obtained in plots planted with whole stalks and the 20-inch seed pieces; the yield from plots planted with hand-cut seed pieces 7 and 13 inches in length were significantly less.

Experiment 4

Procedure: The design of this experiment was a complete randomized block in which yields from plots planted with whole stalks or with stalks cut in half were compared to yields from plots planted with seed pieces about 14 inches in length. The seed pieces were cut and planted by a Don Planter at two planting rates, both less than that for whole stalks. The plot size was 80 x 18 ft., and there were 5 replications.

The seed cane of variety CP 52-68 was hand-cut and topped. The rows for the entire experiment were opened by the Don Planter. The Planter was adjusted to plant on a ridge by moving the guide wheels to their most distant position and by use of the hydraulic system of the tractor to lift the depth wheels above the middles. Used in this fashion, the planter cut the seed pieces and dropped them into the furrow. Most seed pieces were a little more than 14 inches long with one or two nodes; however, as the seed cane was fed into planter base first, the top ends of the cane became seed pieces of irregular length. Planting rates with the

Table 3. Estimated yield from cane (CP 48-103) planted as whole stalks or as seed pieces prepared by hand or combine harvester (Experiment 3)[1].

Cane planted as	Planting rate	Cane (t/a)	Sugar in cane (lb/t)	Sugar (lb/a)
Whole stalk	2	31.8 ab[2]	253.2 a	8055 a
Seed piece				
Hand-cut				
(20 in.)	2	32.5 a	249.9 ab	8107 a
(13 in.)	2	28.2 b	244.8 abc	6895 b
(7 in.)	2	25.2 b	240.1 bc	6041 b
Combine-cut (ave. 14 in.)	2	20.2 c	236.3 c	4797 c

[1] Planted October 7 and 8, 1973; harvested December 5, 1974.

[2] Column means followed by the same letter are not significantly different at the 5% level of probability.

Table 4. Comparison of yields from cane (CP 52-68) planted as whole stalks and as seed cut and planted by the Don Planter (Experiment 4)[1].

Cane planted as	Planting rate	Cane (t/a)	Sugar in cane (lb/t)	Sugar (lb/a)
Whole stalks				
entire	2	28.7 a[2]	231 a	6637 a
halved	2	26.2 ab	232 a	6070 ab
Seed pieces (Don Planter)				
14 in.	1 to 2	23.7 bc	226 a	5347 bc
14 in.	1	20.5 c	224 a	4595 c

[1] Planted October 17, 1972; harvested December 6, 1973.

[2] Column means followed by the same letter are not significantly different at the 5% level of probability.

Table 5. Estimated yield from cane (CP 61-37) planted as whole stalks and as seed pieces prepared by a combine harvester (Experiment 5)[1].

Cane planted as	Soil cover	Planting rate	Estimated cane (t/a)	Sugar in cane (lb/t)	Sugar (lb/a)
Whole stalk	Light[2]	2	53.6 a[3]	218 a	11676 ab
	Deep	2	54.8 a	219 a	12006 a
	Deep	1	40.4 b	225 a	9091 b
Seed piece (Ave. 11 in.)	Light	2	24.8 c	217 a	5388 c
	Deep	2	26.4 c	212 a	5588 c

[1] Planted December 13, 1974; harvested November 18, 1975.

[2] Light cover is 2 to 3 inches of soil after planting, and deep is 3 to 4 inches.

[3] Column means followed by the same letter are not significantly different at the 5% level of probability.

planter varied according to the setting of the machine and the rate of feeding of the seed cane. With two persons feeding seed cane alternately, the planting rate approached 1; when both persons fed simultaneously, the planting rate was obviously more than 1 but less than 2. There was no evidence that the adhering leaf sheaths and blades of the seed cane caused any mechanical problem in the Don Planter.

The treatments involving whole stalks were planted by hand at the rate of two running stalks. In one of the two treatments, each stalk was cut in half after it was in the furrow.

Results: The results (Table 4) indicated that the plots planted with uncut whole stalks yielded significantly better than those planted with 14-inch seed pieces with the Don Planter, both in cane and in sugar per acre. The stalks that had been cut once were intermediate in yield, neither significantly worse than uncut whole stalks, nor significantly better than the higher planting rate with the Don Planter, but both stalk treatments were significantly better in yield than those obtained with the Don Planter at the lower planting rate. Sugar per ton of cane was not significantly different among treatments.

Experiment 5

Procedure: The design of this experiment was a complete randomized block in which the yield from combine-cut seed pieces was compared with that from whole stalks as a function of soil cover after planting. The plot size was 16 x 6 ft, and there were 4 replications per treatment.

Seed cane of the variety CP 61-37 was provided by the South Coast Corporation in Raceland, La. Billets used as seed pieces came from a combine harvester (Massey-Ferguson Model 102 modified for Louisiana by the manufacturer); whole stalks were harvested by hand.

The combine-cut seed pieces had an average length of 10.7 inches, and a range from less than 4 to 18 inches. The average node number per seed piece was 1.9, with a range of 0 to 5 nodes. On the average, there were 1.6 undamaged buds per seed piece.

Because of the wet soil conditions, the depth of cover of soil after planting had to be adjusted with a disc cultivator. Light cover (LT) was about 2 to 3 inches of loose soil and deep cover (DP) approximately 3 to 4 inches.

Millable stalks were counted August 28, 1975, and the cane was harvested and sampled on November 18. The yields were estimated from the millable stalk number and the average stalk weight and sucrose content of the 15-stalk sample.

Results: The estimated yield in cane and sugar per acre was significantly less for the plots planted with combine-cut seed pieces than for plots planted with whole stalks at a planting rate of 2 or 1 (Table 5). There were no significant differences in yield as a result of the small differences in depth of soil cover following planting. The poor germination and stand in plots planted with combine-cut seed pieces were responsible for this reduction in yield; the sugar per ton of cane and the average weight per stalk were not significantly different when cane from combine-cut seed pieces and from whole stalks were compared.

DISCUSSION

The effect of varieties on yield (Table 1) is well known and not directly pertinent to this investigation.

Other than varieties, the factors likely to affect yield in these experiments are seed preparation, seed size, planting date, planting rate, and soil cover after planting. These factors are likely to affect yield primarily through stalk number and not through average stalk weight nor through the level of sugar per ton; however, a poor stand may increase the chance of survival of late tillers containing less sugar and having more trash, and this can reduce the level of sugar per ton of cane (Experiment 3: combine-cut seed pieces).

The method of seed preparation influences the yield significantly. Plots planted with seed pieces prepared by several combine harvesters yielded less than plots planted with seed pieces cut by hand or with whole stalks (Tables 2, 3, 5); in these experiments, planting rate was not a variable. The combine-cut seed pieces, besides their short length, show obvious mechanical damage, and their relatively poor yield is probably its result (1); the October and December planting (Experiments 3 and 5) no doubt increased the vulnerability of the damaged seed pieces.

The plots planted by the Don Planter gave satisfactory yields (Table 4) even though they yielded significantly less than those planted with intact whole stalks at a somewhat higher planting rate. Experiments with the Don Planter were discontinued when the yield results indicated no advantage in planting rate. These results suggest, however, that the Don Planter is better than the combine harvester in preparing viable seed pieces mechanically.

Hand-cut seed pieces, 11 to 20 inches long, when planted at the same rate as whole stalks, yielded as well as whole stalks (Tables 2, 3). Seed pieces also yielded well in Experiment 1 (Table 1), though they consistently yielded less well than whole stalks planted at twice or four-fold the planting rate. The results with hand-cut seed pieces indicate that in this range of sizes they are a satisfactory planting material under Louisiana conditions.

With favorable growing conditions, the one-node seed pieces can perform well (3). When these conditions are not entirely met, the results are less satisfactory.

The influence of planting date on yield varies with varieties (7); a poor performance of October-planted L 62-96 is expected (Table 1). Within a variety, the yields of plots planted with whole stalks and those planted with seed pieces vary together when dates of planting are compared (Table 1).

When the planting rate varied (Tables 1, 4, 5), the plots planted at the lower rate tended to yield less well than the plots planted at the higher rate; although the differences were not always statistically significant, the trend is noticeable whether whole stalks or seed pieces are planted at the lower rate.

The depth of soil cover after planting may affect the stalk population in the spring (Experiment 2) and the yield in the fall (Experiment 3). In these experiments, lighter cover favored better stand and yield. Even with differences in soil cover as marked as 2 and 5 inches in Experiments 2 and 3, the interaction of soil cover and seed preparation was not statistically significant (at 5% probability) for yield of cane and sugar per acre and sugar per ton cane. The small differences in depth of soil cover in Experiment 5 had no apparent effect on yield (Table 5).

In the last several years, with rain preceding freezing weather, seed cane barely covered during the winter has shown excellent germination in the spring. It is not surprising, therefore, that the addition of soil to cane which was lightly covered at planting (Experiment 2) has shown no beneficial effect on yield. Although severe cold following a dry period is infrequent, it does occur in the sugarcane area of Louisiana (5). The addition of soil before the onset of winter may be worthwhile insurance to protect the buds and shoots of cane lightly covered at planting.

The results obtained in the present experiments extend the results, if not the conclusions, drawn from previous research. In the experiments of Arceneaux (2), two-bud seed pieces outyielded whole stalks in pounds of sugar per acre (for the sum of plant cane and first stubble) in two of ten comparisons. When the ten tests were averaged together, the whole stalks yielded 101.7% of the general mean in sugar per acre, and the two-bud seed pieces yielded 94.3%. Coleman and Abbott (4) reported three experiments comparing plantings of whole stalks and two-node seed pieces; in one of the three, the planting with seed pieces did as well as the whole stalks in tons of seed cane produced. Given the improvement in cultivation practices and the change in varieties, our more consistent success with the planting of short seed pieces is predictable. To further the planting of short seed pieces, a machine capable of preparing seed pieces without the physical damage of the combines needs to be developed.

ACKNOWLEDGMENTS

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INCREASING POPULATIONS FROM MECHANICALLY HARVESTED SUGARCANE SEEDPIECES

B. R. Eiland and J. L. Dean
USDA, SEA, Belle Glade, Florida and Canal Point, Florida

ABSTRACT

Populations and crop yields were measured in a factorial experiment in which two sugarcane varieties (CP 63-588 and CP 65-357), two seedpiece lengths, two fungicides and a control, and a heat treatment and a control were compared. Differences were found in populations of both varieties and the best treatment combination consisted of heat-treatment and long seedpieces. The effect of the fungicides on stands decreased over the growing season. Highly significant differences between yields were found at harvest only for seedpiece length and heat treatment. The best treatment combination resulted in yields about 20% greater than those of the worst treatment combination. Yields of CP 63-588 were increased more by long seedpieces than were those of CP 65-357. Heat treatment increased yields of the long seedpieces more than for the short seedpieces.

INTRODUCTION

Increasing production costs and low sugar prices are forcing cane producers to seek methods of reducing production costs. Planting costs may be reduced by the use of mechanical (chopper) harvesters instead of hand labor to cut seed cane. Mechanical harvesters can deliver cleaner seedpieces than those delivered by a continuous loader. Unfortunately, the seedpieces from mechanical harvesters are shorter and have more physical damage than seedpieces from a continuous loader. Poor stands can result from these seedpieces, and producers compensate for the reduced germination by planting additional seed material.

Methods of improving seedpiece germination and stand have been examined by researchers in many sugar producing areas, including Florida (1,2,4,6,7). Mercurial fungicides improve germination--but their registration for use on sugarcane has been withdrawn by regulatory agencies in the United States. DowKlor, a 50% wettable powder of chlordane, was shown to improve germination in Florida, but its use in sugarcane has been restricted (3). A short hot-water treatment (20 min at 52 C) has been used effectively by the United States Sugar Corporation, Clewiston, Florida, to speed up germination of seed material in its skip-planting program (1). The short hot-water treatment, coupled with fungicides, was also investigated, and the fungicide captafol was found to be most effective (1).

Facilities for the heat treatment of seed cane are usually located at a sugar mill, and the transportation of the treated seed material to the planting field requires considerable time and equipment. As a result the amount of seed cane available for planting operations may be limited. A simple method for stand improvement is needed to reduce the quantity of seed material required in normal planting operations. The objective of this experiment was to determine if a fungicide applied by normal spraying would increase populations when compared to other methods of improving population.

PROCEDURES

In this experiment, we considered four factors that could influence population: (a) variety, (b) heat treatment, (c) seedpiece length, and (d) fungicide. A factorial experiment was conducted to determine how these factors affect population and subsequent yield of mechanically harvested seed material.

The treatments in the experiment resulted from combinations of two varieties (CP 63-588 and CP 65-357), a heat treatment (hot water at 52 C for 20 min) and a control, two types of fungicides (benomyl at 420 g/ha and captafol at 5760 g/ha) and a control, and two seedpiece lengths (25 cm and 45 cm). We used a Massey-Ferguson 201 chopper harvester in the experiment to cut the seed and to cut the cane at harvest. The 25-cm seedpiece length used was the average length normally delivered by that harvester, and the 45-cm length used was obtained by removing one set of the chopping knives from the harvester. The experimental design was a split plot in which varieties were main plots and combinations of the remaining treatments were subplots. Main plots were replicated four times. Subplots were single rows 8 m long and 1.7 m wide. Subplots were separated within a row by a 1-m alley.

Seed material was harvested and heat treated on February 14, 1977, and the cane was planted the next day in organic soil. Two continuous lines of cane, the normal planting rate, were laid in the open furrows, and the plots were hand sprayed with fungicide before the seed cane was covered.

Between the beginning of emergence and harvest, stand was counted 12 times at different intervals, depending upon the expected population change. The cane was harvested on January 11, 1978. The cane from each plot was held in the harvester conveyor for discharge. Citrus tubs mounted on front-end loaders of tractors were used to transport the cane from the harvester to platform scales for weighing (5).

Significant differences between yields and between populations resulting from different treatments were determined by standard statistical procedures (8). All possible relations between yield and population for the different counting dates were tested, and correlation coefficients were calculated.

RESULTS

Excellent populations of cane resulted in all plots in this experiment (Fig. 1 and 2). These results suggested that if we had used a lower than normal planting rate, the resulting treatment differences might have been increased. Shoot populations at 46 days after planting are given in Table 1. The populations are representative of those in the interval between the end of primary shoot emergence and the start of tillering. Highly significant differences were found between populations as affected by seedpiece length, fungicide, and heat treatment. There was a highly significant interaction between seedpiece length and heat treatment, and the long seedpieces responded more to the heat treatment than the short seedpieces. The shoot population when benomyl was used was lower than when no fungicide was used or when seedpieces were treated with captafol. Earlier population counts (data not shown) indicated that seedpieces treated with captafol emerged faster than those treated with other treatments.

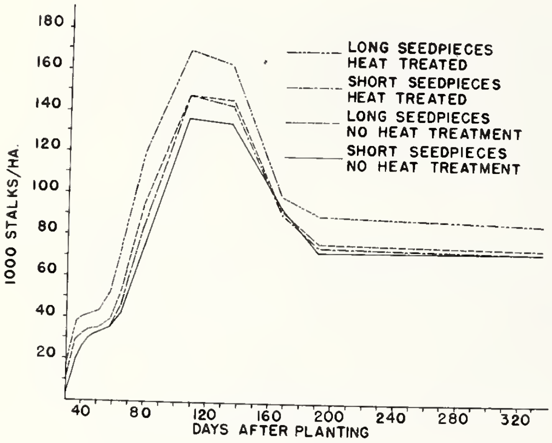

Fig. 1 Sugarcane stalk population over growing season for variety CP 63-588.

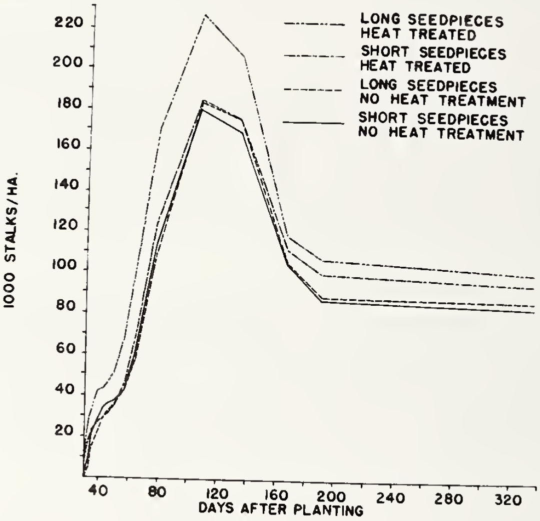

Fig. 2 Sugarcane stalk population over growing season for variety CP 65-357.

Table 1. Shoot populations (1000/ha) 46 days after planting for 2 sugarcane varieties 2 seedpiece lengths, a heat treatment and a control, and 2 fungicides and a control, Canal Point, FL*

		NO HEAT TREATMENT			HEAT TREATMENT		
			FUNGICIDE			FUNGICIDE	
VARIETY	SEEDPIECE LENGTH	NONE	BENOMYL	CAPTAFOL	NONE	BENOMYL	CAPTAFOL
CP 63-588	Short	31.6	29.0	35.5	33.6	32.3	38.4
	Long	31.8	31.8	33.8	42.3	40.6	44.5
CP 65-357	Short	38.4	33.1	39.3	36.6	30.7	30.3
	Long	33.5	30.3	36.0	48.3	44.1	48.7

*Each value shown represents the average of four replications.
Significance at .01 level: Length, heat treatment, fungicide, length X heat treatment, variety X length X heat treatment
Significance at .05 level: Variety

Stalk populations at harvest are given in Table 2. The stalk populations of the two varieties differed because of different growth characteristics. The population of plots planted with heat-treated seedpieces was 9100 stalks/ha greater than that of plots planted with seedpieces that were not heat treated. The short seedpieces of CP 63-588 did not respond to the heat treatment as well as the short seedpieces of CP 65-357. The long seedpieces produced about 5600 stalks/ha more than did the short seedpieces. Seedpieces treated with captafol produced about 3500 more stalks/ha than did untreated seedpieces, whereas those treated with benomyl produced about 1200 less stalks/ha than the untreated seedpieces. Again, heat treatment increased populations for the long seedpieces more than for the short seedpieces for both varieties.

Table 2. Stalk populations(1000/ha) at harvest for 2 sugarcane varieties, 2 seedpiece lengths, a heat treatment and a control, and 2 fungicides and a control, Canal Point, FL*

		NO HEAT TREATMENT			HEAT TREATMENT		
			FUNGICIDE			FUNGICIDE	
VARIETY	SEEDPIECE LENGTH	NONE	BENOMYL	CAPTAFOL	NONE	BENOMYL	CAPTAFOL
CP 63-588	Short	69.3	72.1	78.1	71.1	70.7	77.8
	Long	75.4	70.6	79.2	87.5	83.6	84.9
CP 65-357	Short	83.6	86.7	89.5	99.8	97.1	97.6
	Long	90.1	82.5	95.2	101.7	105.7	103.9

*Each value shown represents the average of four replications.
Significance at .01 level: Variety, length, heat treatment, variety X height
Significance at .05 level: Fungicide, length X height

Stalk population differences found at harvest produced yield differences (Table 3). The yield from seedpieces that received heat treatment averaged about 19 t/ha more than the yield from seedpieces that were not heat-treated. The yield from long seedpieces was about 9 t/ha greater than that from short seedpieces. The long seedpieces responded more to heat treatment than the short seedpieces. The yield from CP 63-588 was greater with the long seedpieces than was the yield from CP 65-357 with the long seedpieces. The statistical analysis indicated a difference in yield between replicated blocks. This difference in block yields can be attributed to two blocks of the experiment in which CP 63-588 became recumbent and probably stopped growing for a period of time. Fungicides did not influence yields at harvest.

Table 3: Harvest yields (t/ha) of 2 sugarcane varieties, 2 seedpiece lengths, a heat treatment and a control, and 2 fungicides and a control, Canal Point, FL*

		NO HEAT TREATMENT			HEAT TREATMENT		
			FUNGICIDE			FUNGICIDE	
VARIETY	LENGTH	NONE	BENOMYL	CAPATAFOL	NONE	BENOMYL	CAPTAFOL
CP 63-588	Short	118.5	131.8	126.6	137.4	133.3	143.5
	Long	132.1	129,5	140.0	165.3	157.7	155.4
CP 65-357	Short	127.3	121.1	126.3	144.7	137.8	136.0
	Long	118.6	114.6	136.6	144.7	150.2	146.1

*Each value shown represents the average of four replications.
Significance at . 01 level: Length, heat treatment
Significance at .05 level: Replications, variety, variety X length, length X height

Fig. 1 and 2 illustrate the stalk population dynamics between germination and harvest for the two varieties. An analysis of the correlation between counting dates and yield indicated that stalk counts on 12 dates, beginning on March 15, 1977 and ending January 11, 1978, were indicative of final yields (Table 4). The correlation coefficients for stalk population and yield for the two varieties were highly significant on all counting dates. The highest values of the correlation coefficient of stalk populations and yields were obtained for stands in August and September, after the populations peaked in June and July. The highest populations were in plots that had heat-treated, long seedpieces. The population of CP 63-588 peaked at about 170,000 stalks/ha, whereas the population of CP 65-357 peaked at about 220,000 stalks/ha. The heat-treated, long seedpieces maintained about a 10-day advantage on stand emergence during the tillering period. This advantage resulted in higher peak populations and a higher final population and yield than those for short seedpieces that were not heat-treated.

Table 4. Correlation coefficients for stalk populations and harvest yield on 12 dates for two cane varieties*

	Variety				Variety	
Date	CP 63-588	CP 65-357		Date	CP 63-588	CP 65-357
3/15/77	.682	.650		5/27/77	.671	.590
3/21/77	.635	.620		6/22/77	.666	.606
3/28/77	.630	.518		7/26/77	.533	.585
4/08/77	.710	.647		8/19/77	.841	.890
4/15/77	.715	.693		9/28/77	.850	.893
4/29/77	.741	.637		1/11/78	.726	.832

*All correlation coefficients are significant at .01 level.

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EFFECTS OF PLANTING RATES ON YIELDS OF SUGARCANE IN FLORIDA

Edwin R. Rice
Federal Research Science and Education Administration
U. S. Department of Agriculture
Canal Point, Florida 33438

ABSTRACT

The expansion of the Florida sugarcane industry in the early 1960's resulted in increased acreage and various planting rates. A 3-year study of 1, 2, and 3 lines of seedcane of three commercial varieties revealed that the single line planting was superior to the other planting rates.

These results prompted additional testing, and another 3-year study of the same planting rates with six commercial varities was made. The data showed that single line plantings were superior to the other planting rates for Cl 41-223 and CP 63-306. The average tons of cane per acre for the three crops of all varieties was 54.0, 55.2, and 54.9 tons for the 1, 2, and 3 line plantings, respectively. These data suggest that additional seedcane beyond that required for an adequate stand of cane is unnecessary.

INTRODUCTION

Sugarcane growers and scientists are interested in determining the planting rate that will produce maximum yields of cane and sugar. In 1953, Hebert found that the planting rate with 2 whole stalks placed side by side with a 10% overlap was optimum for Louisiana (1). Matherne reported in 1971 that varieties do not respond alike when planting rates are increased above the standard rate (2). While 2 stalks and a 10% overlap are used as the Louisiana standard, higher rates give increased yields when mosaic-infested seedcane is planted (3).

Sugarcane is planted on 5-foot rows in Florida, and the planting rates vary considerably. Rates ranging from 1 to 4 lines of seedcane in the furrow have been observed. Seedcane of new varieties is often expensive and scarce; thus, it is important to determine the proper amount of seedcane to be placed in the furrow in order to produce an optimum stand of cane.

MATERIALS AND METHODS

Two experiments were planned to determine the effects of planting rates on yields. Experiment A was conducted on Terra Ceia muck at the Sugar Cane Growers Cooperative of Florida, near Belle Glade, Florida, during the 1967, 1968, and 1969 harvest seasons. Three commercial varieties (Cl 41-223, CP 50-28, and CP 56-59) were planted in a split-plot design on October 14, 1966. The main plots were planting rates of 1, 2, and 3 lines of seedcane in each furrow, with varieties being sub-plots. Each sub-plot was 4 rows wide and 30-ft. long, with 4 replications. All treatments received 300 pounds of 0-0-50 fertilizer per acre at planting time.

Experiment B was conducted on Terra Ceia muck at Hatton Bros., Inc., located 10 miles east of Pahokee, Florida, during the 1972, 1973, and 1974 harvest seasons. Six commercial varieties (Cl 41-223, CP 56-59, CP 62-374, CP 63-306, CP 63-588, and L 61-49) were planted in a split-plot design on November 29, 1971. The main plots were planting rates of 1, 2, and 3 lines of seedcane in each furrow, with varieties being sub-plots. Each sub-plot was 4 rows wide and 35-ft. long, with 3 replications. All treatments received 500 pounds of 0-0-50 fertilizer per acre at planting time.

Millable stalk counts were made in the plant-cane crop of Experiment B.

Both experiments were planted by hand and precaution was taken to protect the buds during the handling of the seedcane. Whole stalks were placed in the furrows and cut into 18 to 20 inch pieces. Stubble cane in both experiments was fertilized on the basis of standard practices for adjacent plantation fields.

After burning, the cane in all plots was cut by hand and weighed. Fifteen full-length stalks were taken at random from each replication at each of the 6 harvests for juice analysis.

RESULTS AND DISCUSSION

In experiment A, all varieties in the plant-cane crop showed slight, but non-significant, increases in yield as the planting rates were increased (Table 1).

First-stubble results showed that the single line planting of all varieties yielded as well as other planting rates. Yields of CP 50-28 and CP 56-59 decreased as the rate of planting increased, but not

Table 1. Yields of cane in tons/acre as influenced by rate of planting at Sugar Cane Growers Cooperative of Florida farm (Experiment A).

Planting rate	Varieties			Average for Planting Rate
	Cl 41-223	CP 50-28	CP 56-59	
		Plant Cane		
1 line	76.51	92.79	102.64	90.65
2 lines	76.78	100.58	102.81	93.39
3 lines	77.20	104.32	108.06	96.53
Average	76.83	99.23	104.50	N.S.
		1st Stubble		
1 line	51.62	65.52	63.91	60.35
2 lines	46.20	65.51	59.95	57.22
3 lines	48.07	63.71	55.03	55.60
Average	48.63	64.91	59.63	N.S.
		2nd Stubble		
1 line	28.82	58.15	42.48	43.15
2 lines	19.01	39.90	27.70	28.87
3 lines	17.84	36.44	24.60	26.29
Average	21.89	44.83	31.59	*
		All 3 Crops		
1 line	52.32	72.15	69.68	64.72
2 lines	47.33	68.66	63.49	59.83
3 lines	47.70	68.16	62.56	59.47
Average	49.12	69.66	65.24	N.S.

*Statistically different - LSD .05 - 4.90 for planting rates in second stubble.
N.S. - Not statistically different at the .05 level of probability

Table 2. Yields of cane in tons/acre as influenced by rate of planting at Hatton Bros. farm (Experiment B).

Planting Rate	Varieties						Average for Planting Rate
	Cl 41-223	CP 56-59	CP 62-374	CP 63-306	CP 63-588	L 61-49	
			Plant Cane				
1 line	59.18	76.82	81.43	77.16	64.06	64.33	70.50
2 lines	62.78	84.15	90.22	73.38	74.23	60.72	74.25
3 lines	64.55	82.78	82.29	75.38	69.17	65.54	73.28
Average	62.17	81.25	84.65	75.31	69.15	63.53	N.S.
			1st Stubble				
1 line	36.86	51.15	50.83	57.04	38.38	45.70	46.66
2 lines	31.17	58.66	59.80	48.50	41.90	49.53	48.26
3 lines	30.73	53.98	57.10	50.79	37.16	55.58	47.56
Average	32.92	54.60	55.91	52.11	39.15	50.27	N.S.
			2nd Stubble				
1 line	39.95	47.07	44.68	53.43	41.54	42.60	44.88
2 lines	32.83	47.15	46.08	48.99	39.62	43.50	43.03
3 lines	32.11	49.09	46.73	50.85	37.79	46.07	43.77
Average	34.96	47.77	45.83	51.09	39.65	44.06	N.S.
			All 3 Crops				
1 line	45.33	58.35	58.98	62.54	47.99	50.88	54.01
2 lines	42.26	63.32	65.37	56.96	51.92	51.25	55.18
3 lines	42.46	61.95	62.04	59.01	48.04	55.73	54.87
Average	43.35	61.21	62.13	59.50	49.32	52.62	N.S.

N.S. Not statistically different at the .05 level of probability.

significantly so.

Results from second stubble showed that all varieties decreased in yield as the planting rate increased. In the average of planting rates for all varieties, the single line planting rate yielded significantly more tons of cane per acre than the double and triple line planting rates. There were no significant differences between the double and triple line planting rates in any of the three varieties.

In the average of all crops, the single line planting rate equaled the higher planting rates.

In experiment B, plant-cane and first-stubble results showed that the 2-line plantings of CP 56-59, CP 62-374, and CP 63-588, were slightly higher than the 1 and 3-line plantings (Table 2). The 1-line plantings were equal to the higher rates in the average of all varieties. Average yields from the 3-line plantings were not significantly higher than the single line plantings in both plant and first-stubble crops.

There were no significant differences among planting rates for yields in second stubble in experiment B. In the average of all varieties, the single line planting was equal to yields from higher planting rates.

In the average of all crops there was no siginificant difference in yields from the 3 planting rates.

Millable stalk counts from the average of all varieties in the plant-cane crop showed an increase in the number of stalks as the planting rate was increased (data not shown).

Significant differences in yields of sugar/ton occurred only among varieties and there were no significant variety X rate of planting interactions in either experiment. There were no significant differences for stalk weight among the 3 planting rates (data not shown).

Mathern (2) showed that varieties respond differently to various planting rates; however, in experiment A, the 3 varieties responded similarly, but there were significant differences among planting rates in the second-stubble crop. In experiment B, there were no significant differences among planting rates in any of the 3 crops.

These experiments were planted with fresh, firm, and disease-free seedcane and more care was taken in the planting process than would have been the case in the average commercial operation. The results suggest that with proper handling of the seedcane at planting, additional seedcane beyond that required for an adequate stand (one line) of cane is unnecessary.

ACKNOWLEDGMENT

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RESPONSE OF CLEWISTON (CL) VARIETIES TO POLARIS^R IN SMALL PLOT AND COMMERCIAL SCALE TESTS DURING THE 1977-78 HARVEST

D. G. Holder, R. P. DeStefano, J. D. Stacy, and J. W.Beardsley, Jr.
United States Sugar Corporation
Clewiston, Florida 33440

ABSTRACT

Several Clewiston (Cl) varieties were tested for their response to Polaris on a commercial scale during the 1977-78 harvest in the plantations of United States Sugar Corporation. Cl 54-336, Cl 54-378, and Cl 65-260 had significant increases in yield (yield of 96^o sugar percent cane) of 13.8%, 7.2%, and 7.4% respectively when treated at 3 pounds Polaris/acre. Cl 59-1052 had a significant increase of 7.4% when data from 3, 3.5, and 4 pounds Polaris/acre were pooled. Cl 65-279 averaged 7.4% higher in yield when treated at 3 pounds Polaris/acre in three replications. Cl 61-5 averaged 12.7% higher in yield in Polaris treated fields when data from one replication each of 2, 2.5, and 3 pounds Polaris/acre were pooled. Cl 41-223, Cl 54-312, Cl 61-205, and Cl 65-294 showed potential of responding to Polaris at 3 pounds/acre with increases in yield of 5.1% to 19.0% in unreplicated tests. Cl 49-200 did not respond in an unreplicated test. In small plot screening tests the unreleased varieties Cl 61-620 and Cl 68-575 showed potential for response to Polaris.

INTRODUCTION

The amount of sugarcane treated with glyphosine [N, N-bis (phosphonomethyl) glycine], a sugarcane ripener, has increased steadily in recent years in Florida. The acreage treated with the ripener, marketed as Polaris^{R1}, grew from 178 acres in 1972 to 22,000 acres in 1977 (1). These figures include commercial acreage and commercial tests. Tests with the ripener on the plantations of United States Sugar Corporation have indicated that Clewiston (Cl) varieties differ in their degree of response to the ripener. Therefore, we conducted commercial scale and small plot tests during the 1977-78 harvest to gain additional information about the responsiveness of several key varieties.

MATERIALS AND METHODS

Commercial Tests. Commercial fields selected for the Polaris study were divided with one half-field randomly assigned as the check and the other half-field as the treated area, so for statistical purposes each field represents a replication. The half-field size ranged from 15.1 acres to 37.5 acres, with the treated and check area having about equal acreage in each replication. Monsanto's 1977 commercial 85% wettable powder formulation of Polaris was used. All rates are expressed in pounds of the commercial formulation per acre. Polaris was applied in five gallons of water containing 0.3 ounces of a drift control agent (Nalco-trol^{TM2}) per acre by fixed wing aircraft. All treatments were applied before noon during the period September 26 to October 31. There was no rain in the six hours following treatment.

The cane was harvested 5 to 8 weeks after treatment and followed through the mill. Two harvest methods were employed, but in each replication the harvest method was the same. In hand harvest, the cane was cut by hand and placed in pile rows, then picked up by a continuous loader and cut into billets before being delivered to the mill. In machine harvest, standing cane was cut and loaded by United States Sugar Corporation's chopper harvester. At the mill, crusher juice was analyzed for brix, sucrose, and purity; and theoretical yields of sugar were calculated according to the formula:

$$\% \text{ yield } 96^o \text{ sugar} = Sx - By$$

where S and B are crusher juice sucrose and brix, respectively (2,3). Sucrose and brix reduction factors (x and y, respectively) required by this treatment were based on the average mill performance data for the previous five years. Tons cane per acre (TC/A) and yield of sugar were utilized to calculate pounds sugar per acre.

Varieties Cl 54-336, Cl 54-378, Cl 59-1052, and Cl 65-260 were treated in four or more replications. Cl 61-5 and Cl 65-279 were treated in three replications, Cl 41-223 was treated in two replications, and Cl 49-200, Cl 54-312, Cl 61-205, and Cl 65-294 were screened in unreplicated trials. A randomized complete block was used for statistical analyses when there were four or more replications per variety.

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[1] ^{R}Polaris is a registered trademark of the Monsanto Company.

[2] Trademark of Nalco Chemical Company.

Small Plot Screening. Small plot screening trials were conducted in 1/50 acre plots (4 rows on 5 ft. centers x 43.6 ft.). The middle two rows were treated for 25 ft. and the remaining ends of these rows served as the check. A portable sprayer charged by compressed CO_2 was used to apply the ripener. Again the commercial Polaris was used, but with no additives. The ripener was applied in 30 gal. water/acre on October 18-19, 1977 between 8:00 and 9:00 AM. The wind was less than 6 mph, and there was no rain in the six hours following application. At six weeks post-treatment (November 29-30, 1977), ten-stalk samples of cane were hand cut, cleaned, topped at the top joint, and milled in a three-roll mill. Brix and pol were measured, and calculations were made to evaluate juice quality and yield of sugar. Since the cane was clean, 1977-78 core punch factors for the Clewiston mill were used in calculating yields (2,3).

Commercial and experimental varieties were screened in the small plots. Cl 59-1052 was treated in two tests. Polaris was applied at 3.5 lbs/A in the first and 4 lbs/A in the second test. The cane was third stubble, and there were four replications in each test. Cl 65-260 and Cl 65-294 were each treated at 3 lbs. Polaris/A in four replications of first stubble. Cl 61-620, Cl 65-279 and Cl 68-575 were each treated in two replications of 3 lbs. Polaris/A in first stubble. Cl 65-260 was included in these tests as a responsive check.

RESULTS AND DISCUSSION

Commercial Tests. Data on juice quality were more consistent than data on cane tonnage in the trials. It should be noted that such influences as insects and the freeze of January 17-21, 1977 may have resulted in stand differences and caused difficulty in obtaining ideal pairs to test. We have no previous data to indicate that Polaris causes changes in tons cane/acre (TC/A) in Florida. Therefore, equal TC/A (average TC/A of all fields of the variety in the test) is sometimes used in this text for comparative purposes.

Variety Cl 54-336, treated with Polaris at 3 lbs./A, had significant increases in brix and sucrose (Table 1). Although not significantly different, purity was higher in five of the eight replications. Yield was increased 1.24 points (13.8%) which was highly significant. Cane tonnage was almost unchanged in this variety, and sugar/A showed a significant increase of 773 lbs. Assuming equal production of 31.23 TC/A, there would have been an increase of 774 lbs. sugar/A due to Polaris treatment. Seven of eight replications were machine harvested, and all cane was plant or first stubble.

Cl 54-378 showed significant increases in purity and nonsignificant increases in Brix and sucrose when treated with Polaris at 3 lbs/A (Table 1). Yield of sugar was increased 0.74 points (7.2%) which was significant. The tons cane/A and pounds sugar/acre were lower in the Polaris treatments than in the checks. If one considered equal production of 31.33 TC/A, there would have been an increase of 320 lbs. sugar/A due to Polaris treatment. Four of five replications were hand harvested, and the age ranged from plant cane to fifth stubble.

Cl 59-1052 was treated in four replications of 3.5 lbs. Polaris/A and one replication each of 3 and 4 lbs./A. For statistical purposes, the results were summarized as six replications of Polaris vs. check (Table 1). Brix and sucrose were increased significantly by the Polaris treatment, and, while not significant, purity was higher in five replications. Yield was increased 0.86 points (7.4%), which was significant. The actual cane production averaged less in the treated cane, but sugar/A was 116 lbs./A greater. If one considered equal production of 35.54 TC/A, there would have been an increase of 611 lbs. sugar/A. Five of six replications were hand harvested, and the cane ranged from plant to third stubble.

In Cl 65-260, which was treated at 3 lbs. Polaris/A, brix and sucrose were significantly increased, and average purity was higher. Yield was increased 0.95 points (8.2%) by Polaris, which was highly significant. Actual tons cane/A was about equal, and there was an increase of 645 lbs. sugar/A with the treatment. If equal production of 36.28 TC/A were considered, there would have been an increase of 690 lbs. sugar/A. All four fields were hand cut, and the cane was either plant or first stubble.

Cl 61-5 was treated with Polaris at 2, 2.5, and 3 lbs./A in one replication at each rate. The averages for the three rates are presented since the results were similar (Table 2). Even though there was a small number of replications, the consistency of the data and the magnitude of the changes should make the results reliable. There were large increases in brix, sucrose, and purity in the treated cane. The yield averaged 1.40 points (12.7%) higher in Polaris treatments, and, based on the actual TC/A, there was an increase of 635 lbs. sugar/A. If equal cane of 30.63 TC/A had been produced, there would have been an increase of 858 lbs. sugar/A. Two fields were machine harvested, and all cane was first stubble.

Treating Cl 65-279 with 3 lbs. Polaris/A produced large increases in brix and sucrose (Table 2). Even though there was a small number of replications, the consistency of the data and the magnitude of the changes should make the results reliable. The yield averaged 0.83 points (7.4%) higher in the treated cane, and based on the actual TC/A, there was an increase of 826 lbs. sugar/A. If equal cane of 33.24 TC/A had been produced, the increase would have been 552 lbs. sugar/A. All fields were hand harvested plant cane.

Table 1. Comparison of Polaris treated and check cane of six varieties which were treated in three or more replications on a commercial scale.

Variety	Polaris rate (lbs/A)	No. repli-cations	Days to milling	Stubble	Crusher juice			Tons cane/A	Yield 96° sugar, % cane	Lbs. sugar/A	Machine or hand harvest
					Brix	% Sucrose	% Purity				
Cl 54-336	CK	8	--	Mixed	16.72	13.66	81.77	31.05	8.98	5,596	Both
	3	8	44	Mixed	18.24	15.33	83.93	31.41	10.22	6,369	Both
	Change				+1.52**	+1.67**	+2.16	+.36	+1.24**	+773*	
Cl 54-378	CK	5	--	Mixed	18.66	15.43	82.64	33.60	10.23	6,843	Both
	3	5	48	Mixed	19.61	16.42	83.64	29.07	10.97	6,327	Both
	Change				+.95	+.99	+1.00*	-4.53*	+.74*	- 516	
Cl 59-1052	CK	6	--	Mixed	19.57	16.93	86.51	36.59	11.60	8,475	Both
	3,3.5,4	6	46	Mixed	20.65	18.07	87.52	34.49	12.46	8,591	Both
	Change				+1.08*	+1.14*	+1.01	-2.10	+.86*	+116	
Cl 65-260	CK	4	--	Mixed	19.67	16.94	86.09	36.42	11.57	8,388	Hand
	3	4	47	Mixed	20.83	18.07	86.74	36.14	12.52	9,033	Hand
	Change				+1.16*	+1.13*	+.65	-.28	+.95**	+645	
Cl 61-5	CK	3	--	1st	19.70	16.34	82.79	31.25	11.02	6,806	Both
	2,2.5,3	3	44	1st	21.10	18.09	85.67	30.01	12.42	7,441	Both
	Change				+1.40	+1.75	+2.88	-1.24	+1.40	+635	
Cl 65-279	CK	3	--	Plt	18.87	16.22	85.94	32.65	11.24	7,342	Hand
	3	3	42	Plt	20.20	17.39	86.09	33.84	12.07	8,150	Hand
	Change				+1.33	+1.17	+.15	+1.19	+.83	+826	

*, ** Significantly different at the .05 and .01 levels, respectively, by analysis of variance. Those changes above dashed line not marked by asterick are not significantly different. No statistical analyses of varieties below dashed line.

Table 2. Comparison of Polaris treated and check cane of five varieties which were treated in one or two replications on a commercial scale.

Variety	Polaris rate (lbs/A)	No. repli-cations	Days to milling	Stubble	Crusher Juice			Tons cane/A	Yield 96° sugar, % cane	Lbs. sugar/A	Machine or hand harvest
					Brix	% Sucrose	% Purity				
Cl 41-223	CK	2	--	4th	19.66	17.24	87.69		11.94		Hand
	3	2	49	4th	21.10	18.75	88.86		13.08		Hand
	Change				+1.44	+1.51	+1.17		+1.14		
Cl 49-200	CK	1	--	1st	17.70	14.14	79.88	38.25	9.35	7,152	Machine
	3	1	43	1st	17.34	14.20	81.89	34.67	9.52	6,601	Machine
	Change				-.36	+.06	+2.01	-3.58	+.17	-551	
Cl 54-312	CK	1	--	1st	19.62	16.85	85.88	41.18	11.56	9,521	Hand
	3	1	37	1st	20.61	17.71	85.93	34.09	12.15	8,284	Hand
	Change				+.99	+.86	+.05	-7.09	+.59	-1,237	
Cl 61-205	CK	1	--	1st	20.18	17.05	84.49	40.06	11.64	9,326	Hand
	3	1	44	1st	21.69	19.01	87.64	37.12	13.23	9,822	Hand
	Change				+1.51	+1.96	+3.15	-2.94	+1.59	+566	
Cl 65-294	CK	1	--	Plt	19.81	16.55	83.54	35.58	11.12	7,913	Hand
	3	1	45	Plt	22.23	19.30	86.82	31.21	13.24	8,265	Hand
	Change				+2.42	+2.75	+3.28	-4.37	+2.12	+352	

Varieties Cl 41-223, Cl 49-200, Cl 54-312, Cl 61-205, and Cl 65-294 were screened at 3 lbs. Polaris/A (Table 2). Of this group, Cl 61-205 and Cl 65-294 showed the greatest potential for response with increases in yield of 1.59 points (13.7%) and 2.12 points (19.0%), respectively. Cl 41-223 and Cl 54-312 increased 1.14 points (9.5%) and 0.59 points (5.1%) in yield, respectively, with treatment. Cl 49-200 had the lowest response with an increase of 0.17 points (1.8%) in yield.

Al "Cl" varieties in the 1977-78 commercial tests were rated responsive except one. The yield increases for Cl 54-336, Cl 54-378, Cl 65-260, Cl 61-5, and Cl 65-279, which were in replicated tests, are considered more reliable. The results with the first four of these generally agree with previous tests. This was the first experience with Cl 65-279. Cl 59-1052 gave a significant response when the 3, 3.5, and 4 lbs/A rates were pooled. Past tests with this variety at 3 lbs/A had given erratic results. We speculate that a more consistent response may be obtained at the higher rate of 4 lbs/A. The response of Cl 41-223 and Cl 54-312 generally agrees with past reports (4) and our experience, while lack of response in Cl 49-200 conflicts with past experience. This was the first experience with Cl 61-205 and Cl 65-294, both of which showed outstanding potential for response to the ripener.

Small Plot Screening. All varieties in the small plot screening tests increased in yield with Polaris treatment, but the range of responses was from very small to large (Table 3). Cl 59-1052 showed little response in the small plots when treated with 3.5 lbs Polaris/A. At 4 lbs/A, the average yield increase was 0.45 points (3.9%), which was not significant, although the individual replications were consistent for the trend. Cl 65-260 averaged 0.46 points (4.0%) increase in yield when treated at 3 lbs Polaris/A. The increase was consistent in the replications but not significant. Cl 65-294 increased 1.03 points (9.2%) in yield with Polaris, which was highly significant. The yield of Cl 65-279 averaged 0.52 points (4.3%) higher in the treated plots. Cl 61-620 averaged 0.46 points (4.4%) increase in yield with Polaris, and Cl 68-575 averaged 1.3 points (12.6%) increase in yield with treatment. As in the commercial tests, there were general increases in brix, sucrose, and purity.

Table 3. Comparison of Polaris treated and check cane of seven varieties in small plots.

Variety	Polaris rate (lbs/A)	No. Replications	Crusher Juice			Yield 96^{o} sugar, % cane
			Brix	% Sucrose	% Purity	
Cl 59-1052	CK	4	21.41	19.64	91.69	11.83
	3.5	4	21.84	20.07	91.89	12.11
	Change		+.43	+.43	+.20	+.28
Cl 59-1052	CK	4	21.08	19.21	91.09	11.54
	4	4	21.68	19.90	91.77	11.99
	Change		+.60	+.69	+.68	+.45
Cl 65-260	CK	4	20.95	19.14	91.34	11.48
	3	4	21.45	19.80	92.32	11.94
	Change		+.50	+.66	+.98	+.46
Cl 65-294	CK	4	20.30	18.41	90.68	11.15
	3	4	21.80	19.99	91.70	12.18
	Change		1.50**	1.58**	+1.02	+1.03**
Cl 61-620	CK	2	19.82	17.79	89.77	10.54
	3	2	20.55	18.52	90.12	11.00
	Change		+.73	+.73	+.35	+.46
Cl 65-279	CK	2	21.20	19.48	91.86	12.12
	3	2	21.95	20.48	92.26	12.64
	Change		+.75	+1.00	+.40	+.52
Cl 68-575	CK	2	19.92	17.98	90.30	10.28
	3	2	22.22	20.17	90.76	11.58
	Change		+2.30	+2.19	+.46	+1.30

**Significantly different at the .01 level by analysis of variance. Those changes above dashed line not marked by asterick are not significantly different. No statistical analyses of varieties below dashed line.

The yield increases for varieties Cl 59-1052, Cl 65-260, Cl 65-279, and Cl 65-294 with Polaris treatment in small plots were about half of those obtained in the commercial trials. Considering that Cl 65-260 is generally responsive, the results with the other varieties are promising. The smaller increases were probably due to sucrose levels being naturally high. Varieties Cl 61-620 and Cl 68-575, both of which will be planted commercially for the first time in the fall of 1978, were screened for the first time. Cl 61-620 showed potential, and Cl 68-575 showed outstanding potential for response to Polaris.

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MATURITY PATTERNS OF SEVERAL
LOUISIANA SUGARCANE VARIETIES

C. A. Richard
American Sugarcane League
New Orleans, La. and
F. A. Martin and G. M. Dill
Louisiana Agricultural Experiment Station
Baton Rouge, La.

ABSTRACT

Maturity data on six commercial sugarcane varieties were collected for three years at the St. Gabriel Farm of the Louisiana Agricultural Experiment Station. Yield components were evaluated throughout the harvest season for both plant and stubble cane. Varietal differences agreed with previously reported maturity classes. Stubble cane was found to have higher initial sucrose and purity than plant cane; however, the rate of sucrose accumulation and increase in stalk weight was greater for plant cane during the harvest season. These data therefore supports the practice of harvesting stubble cane prior to plant cane in Louisiana in order to allow for the greater potential increase of the plant cane crop.

INTRODUCTION

Testing of Louisiana commercial sugarcane varieties in infield, outfield, and maturity test have indicated differences in the relative maturity of these varieties. Although these evaluations are routinely harvested by stubble age (plant cane crop or stubble cane crop), variety and harvest recommendations make little reference to stubble age (8). Consequently, commercial fields of sugarcane are in some cases, scheduled for harvest based on sucrose level rather than stubble age. Therefore, during several harvesting seasons at the LSU Agricultural Experiment Station, St. Gabriel Farm, changes in juice quality and growth rate were monitored to determine:

1. The maturity patterns of sugarcane genotypes with particular reference to crop, and

2. The validity of using only sucrose percent in establishing harvest schedules.

MATERIALS AND METHODS

Commercial and experimental varieties are routinely grown at the St. Gabriel Farm of the Louisiana Agricultural Experiment Station. During the 1974 through 1977 harvest seasons,replicated plots of plant and stubble cane of six commercial varieties (Table 1) were sampled biweekly.

Ten stalk samples were cut flush with the ground, stripped, topped through the apex, weighed, and milled once through a 3-roller mill. For each juice sample, brix was determined by hydrometer, apparent sucrose by polarization, and apparent purity as the ratio of apparent sucrose and brix (13). From these results, the yield of recoverable sugar per ton of cane was calculated by a method previously described (12). The yield of cane per acre was calculated by multiplying mean stalk population per acre by mean stalk weight. Finally, the yield of recoverable sugar per acre was calculated by multiplying recoverable sugar per ton by yield of cane per acre.

There was an average of 38 data points for each variable over the six varieties during the four year period. These variables were analyzed by least squares analysis to determine the best models to relate harvest date and each yield component of interest. These models were used to compare maturity patterns of plant and stubble crops of the six varieties of interest.

RESULTS AND DISCUSSION

Data for stalk weight best fit a linear model while data for normal juice sucrose, sugar per ton and sugar per acre best fit a quadratic model (Table 2).

Biweekly values taken from the best fit curves of normal juice sucrose for the six varieties in both plant cane and stubble cane are shown in Table 3. Two of these varieties, NCo 310 and CP 61-37 are late maturing (2,4) and their sucrose values in this data did not exceed 12.6% in either crop. Two other varieties, CP 67-412 and CP 48-103 have been classified as mid-season maturing varieties (7,3). The data would indicate this to be true since these two have generally higher sucrose values at midseason (Nov. 12) than do the two late maturing varieties. Both CP 65-357 and L 62-96 have been classified as early maturing (6,5) and again this data shows that generally these two varieties have higher sucrose than do the other four varieties in the early dates of the maturation season.

Of more importance is the pattern of maturity of these varieties with respect to crop. It should be noted that the stubble sucrose of each variety generally starts higher than the plant cane sucrose and continues its advantage throughout the season. This is generally accepted as fact for Louisiana sugarcane.

The value of 12% normal juice sucrose has been accepted in Louisiana as par sucrose value (1). The date at which each variety reaches par sucrose was taken from the predicted values of normal juice sucrose and can be seen in Table 4. This summarizes the relative maturity of each of the varieties and the differences between stubble cane maturity and plant cane maturity.

The values of sugar per ton of cane nearly paralleled differences in normal juice sucrose since a very strong association between sucrose and sugar per ton exists (11).

From Table 4 a decision can easily be made as to which cane is best at the early harvest dates and which cane is suited for the late harvest dates. However, at mid-season (third week of October to the third week of November) there are some decisions to be made. Looking only at maturity dates a harvest schedule based solely on sucrose percent would result in the plant cane of the early maturing varieties being harvested before the stubble cane of the late maturing varieties. However, if one considers all yield components, does harvesting plant cane of the higher sucrose varieties before stubble cane of the lower sucrose varieties actually produce higher profits in the current harvest season?

Table 5 shows the average percent weight increase of the six varieties for the two crops during the maturation period. There is an average of 2% faster growth rate in the plant cane crop over the stubble cane crop. Although not statistically different, the early maturing varieties tended to increase in stalk weight slightly faster than the late maturing varieties. This would suggest that early harvest of the plant cane crop would subtract from the full tonnage increase potential. Thus, following only juice quality guidelines for a harvest schedule might not be allowing for the greatest potential increase in crop yields, especially when comparing the percent increase of the plant cane of early maturing varieties with the stubble cane of the late maturing varieties.

For further examination of this point, Table 6 shows sugar per acre. This would approximate a value for payment of sugarcane deliveries. As previously indicated the practice of harvesting older stubble of the highest sucrose varieties in the early portion of the harvest season and the plant cane of the lowest sucrose varieties in the later portion of the harvest season is already followed. These two classes of varieties are the data in the upper right and lower left hand columns of Table 6. The two classes of canes where the decision on harvest schedule is to be made are the plant cane of the early maturing varieties (upper left hand columns) and the stubble cane of the late maturing varieties (lower right hand columns). These decisions are generally made from late October to mid-November. Therefore, for each crop of each class of varieties the sugar values for October 22 and November 21 are listed.

If the harvest schedule were dictated solely by sucrose level, then the plant cane of the early maturing varieties (yield of 6954 lbs. of sugar) would be harvested early and the stubble of the late maturing varieties (yield of 6360 lbs. of sugar) would be harvested later. This would produce a total theoretical yield of 13,314 lbs. of sugar. However, if the harvest schedule were designed primarily by crop, then the stubble cane of the late maturing varieties (yield of 5068 lbs. of sugar) would be harvested early and the plant cane of the early maturing varieties (yield of 8253 lbs. of sugar) would be harvested later. This would produce a total theoretical yield of 13,321 lbs. of sugar. These two totals can be considered practically the same. Therefore, there would be no overall yield or profit increases by following only a sucrose scheduling of the harvest plan. This might result in a penalty for shipping sub-par sucrose cane while harvesting stubble of late maturing varieties in the early part of this mid-season period, but during this time the yield of the plant cane of the early maturing varieties has increased at a faster rate and to a higher level than if the reverse schedule has been followed.

It should also be considered that early harvest of the plant cane crop is damaging to the subsequent stubble crop yields (10).

There may be valid reasons for harvesting plant cane early. However, they would be logistically related reasons such as poorly drained heavy soils, inaccessibility in the late harvest season, etc. As previously stated, plant cane harvested after mid-season generally produces better stubble yields in subsequent crops. These data would indicate that there is no profit increase by harvesting plant cane of early varieties before stubble cane of late varieties. The practice of using only sucrose percent to schedule individual field harvesting is not sound. However, scheduling of field harvest based primarily on crop followed by sucrose percent may be acceptable.

Table 1. Varieties included in this study and the % of the state's acreage they occupied in 1978.

Variety	% of Acreage
CP 65-357	50
CP 61-37	16
NCo 310	10
CP 48-103	8
L 62-96	4
CP 67-412	3
Total	91

Table 2. Best models for the relationship between yield components and time.

Yield Component	Model
normal juice sucrose	$Y = ax + bx^2 + c$
sugar per ton	$Y = ax + bx^2 + c$
stalk weight	$Y = ax + b$
stalk weight x sugar per ton	$Y = ax + bx^2 + c$

Table 3. Predicted values of normal juice sucrose for six varieties across harvest dates.

Variety	Crop	Date of harvest					
		Oct. 1	Oct. 15	Oct. 29	Nov. 12	Nov. 26	Dec. 10
NCo 310	P.C	7.78	9.02	9.87	10.73	11.38	11.74
	STB.	9.04	10.20	11.32	12.08	12.37	12.50
CP 61-37	P.C.	9.04	10.20	10.79	11.24	11.40	11.32
	STB.	10.28	11.21	12.03	12.50	12.61	12.42
CP 67-412	P.C.	8.71	10.27	11.52	11.98	11.93	11.26
	STB.	----	9.60	11.57	12.89	13.54	13.60
CP48-103	P.C.	9.82	11.17	11.97	12.63	12.90	12.84
	STB.	10.33	11.55	12.65	13.29	13.45	13.25
CP 65-357	P.C.	10.52	11.63	12.34	13.03	13.48	13.67
	STB.	10.50	11.58	12.66	13.46	13.81	14.13
L 62-96	P.C.	11.21	12.25	12.85	13.33	13.50	13.42
	STB.	11.31	12.25	13.08	13.55	13.65	13.49

Table 4. Dates at which varieties reached par sucrose (12% NJS).

Variety	Crop	
	Stubble	Plant cane
NCo 310	Nov. 11	-
CP 61-37	Oct. 27	-
CP 67-412	Oct. 31	-
CP 48-103	Oct. 19	Oct. 29
CP 65-357	Oct. 18	Oct. 22
L 62-96	Oct. 9	Oct. 12

Table 5. % weight increase from Oct. 12 to Dec. 1.

	Stubble cane	Plant cane
Late maturing varieties	12%	15%
Early maturing varieties	15%	16%

Table 6. Yields of sugar per acre for six varieties on two harvest dates in the two crops.

Variety	Plant cane		Stubble cane	
	Oct. 22	Nov. 21	Oct. 22	Nov. 21
L 62-96	8897	10162	5320	6383
CP 65-357	7664	9222	6266	7752
CP 48-103	4301	5374	4629	5691
$\bar{x}$	6954	8253	5405	6609
CP 67-412	5683	7000	5356	7303
CP 61-37	5329	7106	5273	5994
NCo 310	5325	6835	4574	5782
$\bar{x}$	5446	6980	5068	6360

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METHODS FOR DISPOSING OF UNHARVESTED SUGARCANE AND THEIR INFLUENCE ON SUBSEQUENT PRODUCTION

G. Kidder and B. R. Eiland
Florida Cooperative Extension Service and USDA
Belle Glade, Florida

ABSTRACT

Sugarcane killed by freezing temperatures frequently deteriorates to the extent that it is not economically harvestable and becomes a disposal problem. Effects of the disposal method on subsequent cane and sugar production were investigated. Before treatments were applied, one set of plots was burned, but the other was not. Treatments consisted of leaving the stalks standing, running a tractor wheel over the row of standing cane, running a rolling chopper-drum over the cane, and mowing with a rotary mower. Under both burned and unburned conditions, subsequent cane and sugar yields were lowest where the cane was left standing and highest where it was run over with the tractor wheel; differences between the standing treatment and the three disposal treatments were greater than differences among the disposal methods. No significant differences in sugar content of the cane were found. Burning prior to applying the disposal treatments resulted in somewhat higher sugar and cane yields in the subsequent crop than not burning. The unharvested cane did not present any serious problems in mechanical harvesting of the subsequent cane crop but dead stalks were observed in all harvested samples and would be a factor in commercial harvesting and processing of cane.

INTRODUCTION

Mature sugarcane killed by cold temperatures is generally harvested for some time after a freeze, despite lowered quality and reduced sugar recovery. Occasionally, however, the quality of the frozen cane becomes unacceptable before the mills can process all of it and some cane is not harvested.

Most of the sugarcane growing in Florida in January 1977 was killed during several nights of freezing temperatures. Although badly frozen cane was milled as long as 7 weeks after the freezes, about 4000 hectares of frozen cane was left unharvested. Sugarcane producers were then interested in the best method for disposing of the unharvested cane.

In Louisiana (3) some growers cut the cane down by backing a rotary mower into the standing cane after burning it. Other growers simply burn the standing cane. They have found that subsequent tractor operations flatten most of the stalks, and few problems arise in the subsequent harvest. Where small areas are concerned, some growers dispose of the cane by cutting it and hauling it from the field.

The method of treating young freeze-damaged sugarcane has been shown to influence yields (1, 2, 4). However, no references could be found to document the effects of disposal methods in mature cane on the yield of the subsequent sugarcane crop. Some methods for disposal of unharvested cane could conceivably be harmful to the subsequent cane crop, as well as expensive and energy intensive. Interference with subsequent field operations is another factor that should be considered.

The objectives of the study reported here were: 1) to compare cane and sugar yields in plots where, in the previous crop year, unharvested cane had been disposed of by different means and 2) to compare cane and sugar yields when cane was burned and not burned before stalk disposal.

MATERIALS AND METHODS

A small field of 10-month-old variety Cl 41-223, plant sugarcane that had been killed by the January 1977 freezes was used for the experiment. The cane, which was grown at the Agricultural Research and Education Center at Belle Glade, was uniform and generally erect. Yield was visually estimated at 130 tonnes of cane/ha. Sixteen adjacent rows of cane were selected for the disposal experiment.

On March 15, 1977, alleyways were mowed across the field to form eight blocks. Standing cane in the four blocks on the southern half of the field was burned, and that in the blocks on the northern half was left unburned. Two randomized complete block experiments with four treatments and four replications were installed, one on each half of the field. Each plot was 6.0 meters (4 rows) wide by 15 meters long. Treatments, performed March 17 and 18, consisted of: 1) leaving the stalks standing, 2) running a tractor wheel over the row of standing cane, 3) running over the cane with a rolling chopper-drum (known locally as a "devil catcher"), and 4) mowing with a rotary mower. An 83-KW hydrostatic tractor equipped with dual wheels was driven at 10 to 16 kph for running over the cane and for pulling the rolling chopper-drum. The "devil catcher" consisted of two steel cylinders, 60 cm in diameter and 1.5 m long, with eight equally spaced, tranverse blades protruding 15 cm from the drum. A 1.8-m rotary mower powered by a 34-KW single-wheeled tractor was used for the mowing treatment.

The plots were fertilized by hand on May 24, 1977. No weed control was necessary. The number of millable stalks/ha was estimated on September 19, 1977, by counting the stalks in 3.28 m of the two center rows of each plot.

In preparation for harvest of the first ratoon crop the next year, all 32 plots were burned on January 16, 1978. Thus, the burned and unburned terms used subsequently in the text refer only to the treatment of the plant cane prior to application of disposal methods. Twenty-stalk samples were hand-cut, weighed, and milled in a sample mill, and the juice was analyzed for brix and pol. The simplified Winter-Carp-Geerligs formula was used to calculate sugar content of the cane. The cane was harvested on January 18 and 19 with a chopper harvester and a small-plot harvesting system. The cane weight from the middle two rows of each plot was used to determine cane yield/ha. Sugar/ha was the product of the calculated sugar content and the harvested cane weight.

Data from the two experiments, one in the burned and the other in the unburned cane, were analyzed separately by standard statistical methods for randomized complete block experiments. Since the burned/unburned treatments were not randomized, statistical comparison of the disposal methods in the two experiments could not be made.

RESULTS AND DISCUSSION

The leaf trash shading the ground in the unburned area had been expected to limit the weed population there, whereas a flush of weed growth had been expected in the burned area. Weed growth was minimal in both burned and unburned areas and, thus, no weed control measures were used.

Harvest data obtained 10 months posttreatment are presented in Tables 1 and 2. In both the burned and unburned plots the number of millable stalks/ha was considerably lower where the cane was left standing than where other disposal methods were used. The leaves and stalks of the unharvested cane shaded the stubble and effectively reduced the number of tillers. Where the cane was left standing and unburned, the fewer stalks were significantly heavier than those of the other treatments, but the increased stalk weight was insufficient to compensate for the depressed tillering and the net result was lower cane and sugar yields in the subsequent harvest. The same trend was apparent in the burned plots, but the data were not statistically significant.

Table 1. Summary data for disposal treatments in burned cane.

Treatment	Millable stalks	Average stalk weight	Sugar content of cane	Cane harvested	Estimated sugar yield
	thousands/ha	kg	kg/t	t/ha	t/ha
Tractor	73 a[1]	1.32 a	127 a	116.9 a	14.9 a
Chopper	76 a	1.27 a	124 a	116.7 a	14.5 a
Mower	69 a	1.24 a	127 a	115.6 a	14.7 a
Standing	53 b	1.38 a	119 a	107.6 a	12.8 a
Average	68	1.30	124	114.2	14.2

[1] Column values followed by a different letter are significantly different at the 1-percent level according to Duncan's multiple range test.

Table 2. Summary data for disposal treatments in unburned cane.

Treatment	Millable stalks	Average stalk weight	Sugar content of cane	Cane harvested	Estimated sugar yield
	thousands/ha	kg	kg/t	t/ha	t/ha
Tractor	71 a[1]	1.44 b	122 a	113.2 a	13.9 a
Chopper	69 a	1.30 b	124 a	105.0 b	13.0 a
Mower	66 a	1.28 b	125 a	106.4 b	13.3 a
Standing	43 b	1.70 a	118 a	82.7 c	9.8 b
Average	62	1.43	122	101.8	12.5

[1] Column values followed by a different letter are significantly different at the 1-percent level according to Duncan's multiple range test.

The highest cane and sugar yields were obtained from plots where the tractor had run over the cane, although this superiority was statistically significant only in cane yield in the unburned plots. Likewise, the left-standing treatment was the lowest in cane and sugar yield in both burned and unburned plots, but statistical significance resulted only in the unburned plots. The rolling chopper-drum and rotary mower treatments were intermediate in cane and sugar yields, and the two apparently had about equal effects on the yield parameters. Although not statistically significant, the sugar content was noticeably lower in the left-standing treatment than in the other disposal treatments.

Comparison of the averages shown at the bottom of Tables 1 and 2 shows that, in 1978, considerably higher yields of cane and sugar were obtained from plots where the unmillable cane was burned in 1977 than from plots where it was not. Unfortunately, it was not possible to randomize the burned/unburned treatments and a statistical analysis of the comparison was not possible. However, with 12 and 13% more cane and sugar/ha, respectively, in the burned than in the unburned experiment, it seems likely that the higher yields obtained by burning than by not burning are real and that burning the unharvested cane is worthwhile.

When the four disposal methods were considered for ease of accomplishment and for the amount of equipment and energy required, it was obvious that doing nothing was the simplest, followed by running over the cane with a tractor. To accomplish the latter, the tractor driver simply drove the dual-wheeled tractor over the rows, knocking down two rows at a time. Visibility was poor in the unburned cane and it was difficult to stay centered on the row. Centering was not a problem in the burned area. Pulling the "devil catcher" over the cane crushed it to the ground and partially chopped it into short segments. This disposal method required more energy than the first two methods but was still fairly simple and relatively easy. Mowing with a rotary mower required considerably more time and energy to accomplish than any of the other disposal methods tested. The mower was subjected to considerable strain and would be expected to break down under prolonged operation under the conditions existing in a field of unharvested cane.

Most of the old leaves and stalks that were crushed to the ground by the treatments became part of the ground litter before the January 1978 harvest. Much of the dry, leafy litter burned in the 1978 pre-harvest fire, but the lower portions of the old, dry stalks did not burn. In no treatment did the unburned portions of stalks present a problem to the mechanical harvester or interfere with hand cutting of samples. Although many of the old stalks were blown out by the extractor fans of the harvester, some billets of dead stalks were noted in all harvested samples. In commercial cane, this trash material would lower sugar recovery at the mill. Although the old stalks would be separated from the cane in a hand-harvesting operation, the presence of many dead stalks would probably result in complaints from the cane cutters.

CONCLUSIONS

The method used to dispose of unharvested cane influenced sugar and cane yields in the subsequent harvest. Higher cane and sugar yields were obtained when the unharvested cane was burned than when it was not burned. Treatments designed to partially crush to the ground the standing sugarcane material resulted in higher yields of sugar and cane than a treatment in which the material was left standing. Knocking down the unharvested cane by running a tractor wheel over the row resulted in higher yields than using a rolling chopper-drum or a rotary mower to destroy the cane.

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AGRONOMIC RESEARCH AND DEVELOPMENT NEEDS IN SUGAR CROPS

Stephen Kresovich and William T. Lawhon
BATTELLE
Columbus Laboratories
Columbus, Ohio 43201

ABSTRACT

When considering sugar crops as renewable sources of energy and chemical feedstocks, the agronomic goal is to maximize the production of fermentable sugars and combustible organics per unit land area, while keeping the unit costs to a minimum. To accomplish this goal, a multi-disciplinary approach must be taken. This approach includes: breeding and selecting for varieties which have a high percentage of fermentable sugars and fiber, improving cultural practices, e.g., incorporating narrow-row spacing into the cultural practices to maximize biomass yield; designing equipment to plant narrow-row-spaced sugar crops and to selectively harvest this material while it is still green; and developing the full potential of sweet sorghum as an energy crop in temperate regions. Previous technological development has dealt only with the improvement of cultural practices; currently, a long-range program is being designed to include many areas of agronomic investigation to determine the future potential of sugar crops as renewable energy and chemical feedstock resources.

INTRODUCTION

The United States needs additional sources of reliable fuels. Residents of the Midwestern states are especially aware of this fact because, in the last 2 years, shortages of major fuels have led to darkened offices and streets, job layoffs, school closings, and flourishing sales of thermal underwear. What then is the connection between the flourishing sales of long underwear and my presentation here at this meeting? Simply this:

For the past several years Battelle's Columbus Division, along with a number of organizations which include major state agricultural experiment stations, key U.S. Department of Agriculture groups, engineering companies, and consultants, has conducted studies of selected sugar crops (specifically sugarcane and sweet sorghum) under Department of Energy sponsorship. These studies indicate that sugar crops may have considerable potential as sources of fermentable sugars for conversion into fuels (5). However, straightforward implementation of the gasohol concept has a number of drawbacks that renders it unattractive, except in crisis circumstances. Given lead time to develop new agricultural and conversion technologies, the energy balance and economic problems of the gasohol concept may be overcome.

Four broad areas of investigation dominate the future agricultural technology development program of sugar crops for energy production. These include: 1. breeding and variety selection, 2. improving cultural practices, 3. improving equipment, and 4. the development of the potential of sweet sorghum. Success in one area of investigation is not enough to carry the program. All areas of investigation are integral to the implementation and accomplishment of the goals of the program.

BREEDING AND VARIETY SELECTION

Sugarcane and sweet sorghum have been bred exclusively for food uses and for processing by conventional sugarcane milling equipment. The varieties have been selected for their composition and yield at conventional row spacings. Virtually all of these ground rules are changed to a considerable degree when the goal is fuels from biomass. Desirable characteristics which a sugar crop variety should possess for energy production are:

1. High tonnage. To make an impact at any level, high rates of production per unit area are necessary. This entails both breeding and field practices which maximize yields and are not constrained by conventional practices (i.e., breeding for biomass production at narrow row spacings).

2. High fermentable sugar content. For energy production, we are concerned with the levels of all fermentable sugars found in the stalk. Maximizing sucrose content is not enough. Past breeding work has attempted to maximize sucrose and limit the simple (invert) sugar level; for energy, attempts should be made to maximize total fermentable sugar production.

3. High rind fiber content. With the development of the Tilby process, selective separation of the stalk rind and pith can be accomplished. Therefore, instead of being a problem with conventional sugarcane milling, the rind fiber is a valuable by-product which can be used in the production of fiberboard, a plywood-type material.

4. Erect growth. To increase the crop's ability to intercept solar radiation and to aid in mechanical harvesting, erect growth is required.

5. Lodging resistance. Like erect growth, lodging resistance aids in mechanical harvesting. Hopefully, an increase in stalk rind fiber will increase lodging resistance.

6. Tillering capacity. The production of one or two millable stalks is all that may be required. Because of ratooning practices, tillering capacity should be maintained to aid during stress periods.

7. Early maturing. The goal for energy production is to maximize production per unit area. Possibly earlier maturing varieties would lead to a production of two crops in one season or three crops in 2 years.

8. Ratooning potential. Similar to current practices, a variety must be able to ratoon a number of times in order to efficiently decrease production costs.

9. Uniform maturity. This characteristic deals primarily with sweet sorghum. Uniform maturity aids during harvesting and processing activities.

10. Increased cold and drought tolerance. To aid in product availability and to have a greater impact in the energy program. increased cold and drought tolerance are necessary to expand sugar crops' acreage in the United States.

11. Increased disease and insect resistance. If production area is to expand, increased disease and insect resistance is necessary. Possibly with the use of high fiber varieties, sugar crops' resistance to the sugarcane stalk borer will increase.

This list may lack some traits which would be of value for energy production; however, these are the most important ones and should keep the sugar crops breeders busy for some time.

IMPROVING CULTURAL PRACTICES

Currently, the improvement of cultural practices of sugar crops is the only area which has come under intensive investigation for energy production. The data from the series of experiments conducted during 1977 confirmed the hypothesis that use of narrow-row spacings can significantly increase yields of a sugar crop where the growing season is short and less significantly where the growing season is long. In Louisiana, sugarcane yield increased 30 to 60 percent by the use of narrow-row spacing (3, 7). Florida, which has a longer growing season, only had a yield increase of 10 percent (this is possibly due to the effects of not using a site-adapted variety or cultivation of sugarcane on muck soil) (2). With sweet sorghum, which has a relatively short growing period when compared to sugarcane, narrow-row spacing increased Texas yields by 50 percent (6). In Mississippi, narrow-row spacing increased sweet sorghum production per unit area by as much as 25 percent (personal communication with Freeman and Broadhead).

Another area of future improvement is in the use of growth regulators. Not only can these chemicals be used to "ripen" the crop, but in some cases Alexander (1) has found dilute applications of these same chemicals can even increase plant growth rates. Some examples of these growth regulators are Polaris^{R} and MON 8000^{R}.

Finally, drip irrigation may aid in the effort to decrease unit production costs of sugar crops on sandy soils. This has been successfully demonstrated in Hawaii and may prove functional on the mainland when sugar crops are grown for energy production.

IMPROVING EQUIPMENT

The amount of equipment improvement in sugar crop technology development will depend on the cultural practices that are selected as providing the best fuels from biomass system. A basic tenet of this philosophy is that biological potential should not be limited by traditional machinery constraints. That is, if narrow-row spacing shows a potential to increase yields, then equipment should be developed to mechanically plant and harvest narrow-row sugar crops.

General improvements are as follows:

1. Planting equipment and techniques must be designed to mechanically plant narrow-row sugar crops.

2. Harvesting equipment and techniques must be designed to handle large volumes of biomass on narrow rows.

3. To become more efficient, green cane harvesting and a system to separate plant parts selectively are needed. For example, a sweet sorghum harvester that collects the seed head and leaves as well as the stalk would be needed to make the fuels from biomass program a feasible venture.

As was demonstrated at the 1978 USDA Harvesting Field Day in Belle Glade, Florida, all of the major harvesting equipment is designed for harvesting burned cane at conventional row spacings. A major deterrent to narrow-row spacing development has been the lack of equipment.

DEVELOPMENT OF THE POTENTIAL OF SWEET SORGHUM

Without sweet sorghum, the prospects for fuels from biomass from sugar crops would be relatively dim, except in crisis circumstances. Sweet sorghum has an enormous potential; however, development of the appropriate agricultural technology to facilitate achievement of the potential is a major undertaking. Sweet sorghum varieties that are appropriate for the various geographical areas in the United States need to be selected and/or bred (4). The cultural practices that will make sweet sorghum amiable at high yield and at low cost over a maximum harvest season in the corn belt and other major potential sweet sorghum growing regions need to be developed.

Some of the advantages for sweet sorghum as an energy crop are:

1. Cheap to produce
2. Rapid maturing
3. High yielding
4. Doesn't overwinter (unlike sugarcane)
5. Drought tolerant
6. Many useful products (fermentable sugars, fiber, starch, etc.)

The major disadvantages include:

1. Short harvesting season
2. Uneven maturity
3. Juice breaks down fast

All of these factors emphasize that much work is necessary to develop sweet sorghum as a large-scale commercial crop.

CONCLUSIONS

The concept of energy production from sugar crops is feasible. However, agricultural research and development goals, activities, and funding need to reflect the value of sugar crops as an energy source as well as a food source. The sugar crop production system is adaptive and capable of supplying a number of different end-products. We must realize this fact and make full use of its potential.

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ROW SPACING EFFECTS ON BIOMASS AND COMPOSITION OF SUGARCANE IN FLORIDA

G. J. Gascho and S. F. Shih
Agricultural Research and Education Center
Belle Glade, Florida

Variety CP 65-357 was planted in 0.5 meter row spacings to determine the yields of biomass, total sugars, sucrose and fiber throughout the growing season. Above ground biomass in young cane was much higher for the narrow rows than for the wide rows due to high stalk counts which resulted in more complete capture of available sunlight and improved weed control. The advantage of the narrow row spacing decreased with plant age. Dry biomass in May was more than 300 percent higher for the 0.5 meter than for the 1.5 meter row spacing. In October, the advantage was only five percent. In December, one year after planting, 141 and 41 metric tons per hectare of fresh and dry biomass, respectively, were harvested. Total sugar, sucrose and fiber yields reached 17.0, 15.7, and 19.8 metric tons per hectare, respectively, for mature cane at the 0.5 meter row spacing and 15.4, 13.9, and 17.2 metric tons at the 1.5 meter row spacing. The application of glyphosine 6 weeks prior to the final harvest significantly increased yields of both total sugars and sucrose.

INTRODUCTION

Present dependence of the United States on foreign petroleum and anticipated shortages of energy sources in the future have spurred interest in the development of renewable sources of energy within the United States. Capturing solar energy via photosynthesis is of high interest. Sugarcane (Saccharum spp.) is the most efficient crop plant in this regard and is therefore of interest. Additionally the high concentrations and total yields of sugar are readily convertable to fuels, such as alcohol. However, the high potential efficiency of sugarcane is rarely or never achieved due to suboptimal climate, cultural conditions, varieties, etc. Long periods of incomplete canopy cover in Florida, due to suboptimal winter temperatures decrease the yearly efficiency of photosynthesis.

Planting cane in narrow rows will result in early canopy closure and thus in more efficient capture of solar energy. Under the conditions of a short growing season in Louisiana, cane tonnage was more than doubled by decreasing the row spacing from the standard 1.8 m to 0.3 m (Matherne and Irvine, 1978). Sugarcane grown full season in Florida did not respond to narrow row spacing. Rice, (1978) found no statistically significant differences in total cane or sucrose yield per hectare due to row spacings of 0.9 and 1.5 m for two varieties grown for 3 harvests (42 months). The effect of narrow spacing on biomass, fiber and total sugar has not previously been studied in Florida.

The main objective of this study was to determine the monthly biomass, total sugar and fiber yields of a plant crop of sugarcane grown at narrow and standard row spacings. A secondary objective was to determine the effect of a ripener on total sugar accumulation.

MATERIALS AND METHODS

Sugarcane variety CP 65-357 was planted in 0.5 and standard 1.5 m row spacings on December 20 and 21, 1976. Prior to planting the Pahokee muck soil was prepared by repeated disking and broadcast application of 800 kg/ha of a 0-10-40 fertilizer containing small amounts of the micro-nutrients Cu, Mn, Zn and B. Furrows were made on 0.5 m centers in all plots using a field cultivator. Seed cane was planted in double rows in each furrow for the 0.5 m row spacings and in every third furrow for the 1.5 m row spacings. Four blocks of the two row spacings were planted. Each plot was 33.5 m x 24.4 m (0.8 ha).

A preemergence herbicide application of 6 and 4 kg/ha of allidochlor and atrazine, respectively, was applied 2 weeks after planting. Later applications of silvex and dalapon were used to control weeds in the 1.5 m plots and some spot treatments with a portable tank sprayer were required in 0.5 m plots. However, because of the quick canopy closure in the 0.5 m plots much less weed control was required in 0.5 m rows than in 1.5 m. rows. The water table was maintained at about 45 cm except for a period of approximately 5 days in April, 1977, when the plots were flooded due to a rain of about 25 cm.

Above-the-ground biomass was estimated monthly from May to December by counting stalks in 15 m of each of three randomly selected rows in each plot. Fifty consecutive stalks were cut and weighed to obtain the average plant weight. Both fresh and dry weight were obtained by weighing immediately after cutting and again after drying at 70° C. Biomass was calculated as the product of the population and the average plant weight. For the months of August through December the biomass was separated into leaves, stalks, and tops.

Beginning in August all samples were shredded in a Jeffco cutter grinder and disintegrated in a large waring blender. Total sugar was determined colorimetrically after inversion of sucrose and fiber was determined gravimetrically after washing and drying (methods of Smith[1]). Brix was determined in the disintegrated stalk samples using a refractometer; and pol was determined with a polariscope after leading the raw juice.

On October 20, 1977, 'Polaris' (glyphosine), a ripener, was applied by aircraft at 3.5 kg/ha a.i. to one-half of each plot. Field and laboratory determinations in November and December were made on the individual subplots.

All data were submitted to analysis of variance. The experimental design was a randomized complete block for data from May through July and a split plot variation of a randomized complete block for sugar data in November and December, due to the glyphosine application.

RESULTS AND DISCUSSION

All of the experimental cane was frozen to the ground level during the extremely severe freezes of February 19-21, 1977. Most cane recovered well but some replanting was required to fill gaps of greater than 1 m within the row.

Canopy closure was rapid in the 0.5 m rows compared to the 1.5 m rows. Closure was essentially complete by April 15 and May 15 for the 0.5 and 1.5 m row, respectively. Heavy infestations of weeds were controlled both chemically and manually in the wide rows during April and May. Only spot chemical control was needed in the narrow rows.

Differences in populations of stalks in May and June were very large due to row spacing (Figure 1). These differences decreased rapidly in June and remained small but statistically significant to the final harvest in December. The high populations in the narrow rows early in the experiment decreased with time due to plant competition, principally due to shading effects.

Fresh plant weights were not statistically different between the row spacings except for the October sampling (Figure 2). In general, the higher population maintained in the narrow-row spacing did not reduce individual stalk weights. Of interest is the rapid increase in weight during June, July and August and the abrupt leveling of the weights during the period of September through December. The grand growth period of sugarcane in Florida usually extends to about October 15 when winter cooling normally begins. The variety CP 65-357 apparently grows to its potential more rapidly than most other varieties grown in Florida.

Total above-ground biomass was related to stalk population, with large differences due to row spacings early followed by small to nonsignificant differences late in the growing season (Figure 3). The biomass yields were 41.1 and 37.6 metric tons ha^{-1} in December for the narrow and wide rows, respectively, a 10% advantage in favor of the narrow rows.

Total sugar ha^{-1} was affected significantly by row width only for the September sampling (Figure 4). The highest total sugar accumulation was attained by October. The application of glyphosine in October significantly increased total sugar ha^{-1} by 13% over the untreated plots. There was no significant interaction between glyphosine and row width.

The percent of the total sugars as sucrose, as well as the total amount of sucrose, increased with plant age. Sucrose ha^{-1} was always higher for the 0.5 m than for the 1.5 m rows but the difference was only significant for the September samples. Application of glyphosine in October increased sucrose ha^{-1} by 11% over untreated subplots. No interaction was found between glyphosine and row width for sucrose ha^{-1}

No significant differences between the two row widths were recorded for fiber ha^{-1} (Table 1). Fiber yields up to 19.5 metric ton ha^{-1} were obtained in October.

The study indicates that high biomass, sugar and fiber yields can be grown in Florida plant cane fields. The results tend to suggest CP 65-357 matures early, and biomass yields year^{-1} may be increased by harvesting at intervals of less than 12 months. This possibility should be researched even though any multiple harvest scheme will meet with constraints due to seasonal weather changes in Florida which affect growth, sugar concentration and may even result in a loss of the plants in a hard freeze.

Row spacing experiments to study biomass yields, cane composition, and fertility requirements of sugarcane grown for energy purposes are continuing on ratoon crops and on a sand soil.

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[1] Smith, B. A. Personal communication

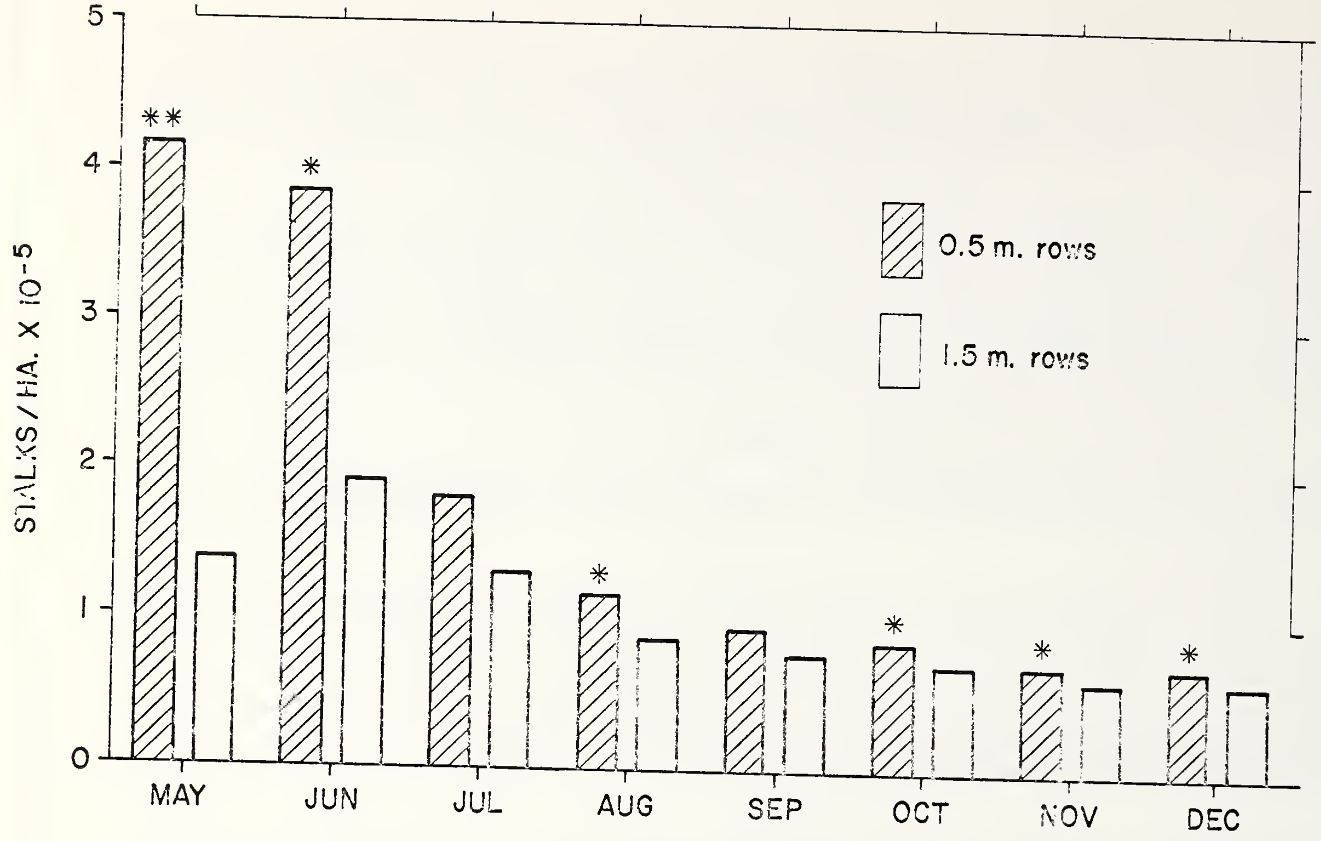

Figure 1. Stalk populations by month at 0.5 and 1.5 m row spacings. ** and * - 0.5 m rows significantly higher at the 1% and 5% levels respectively.

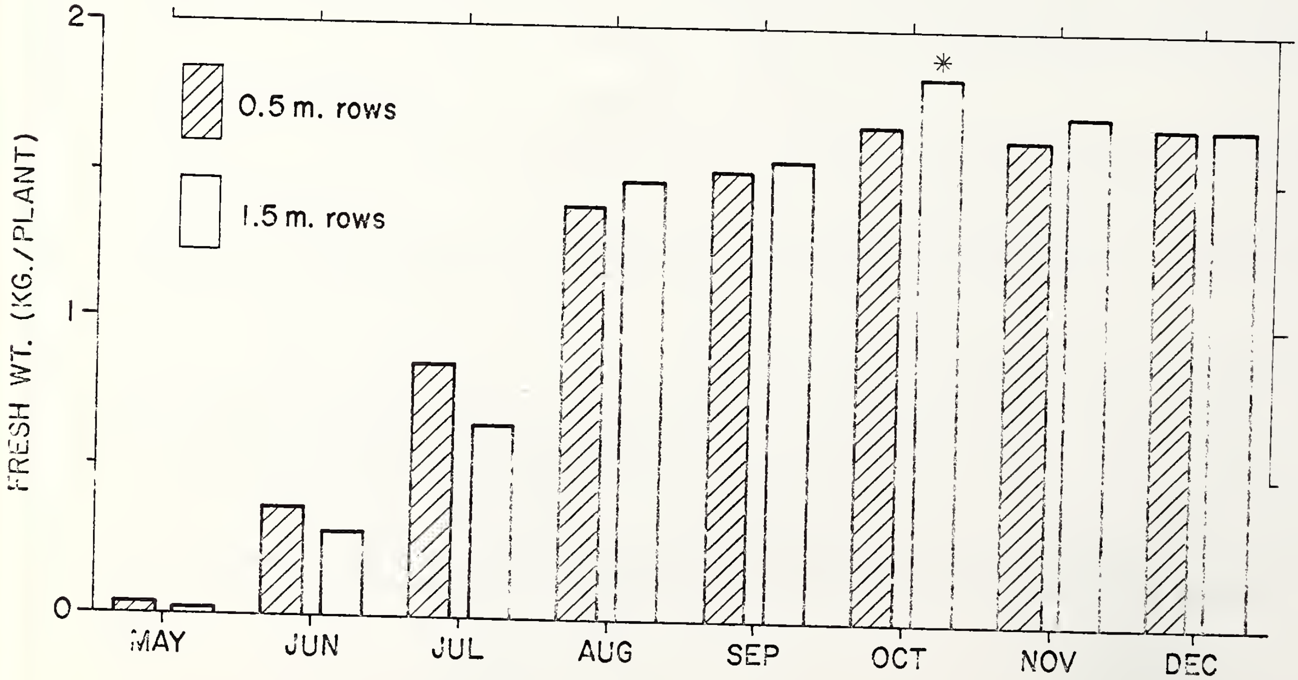

Figure 2. Fresh weight per plant by month for 0.5 and 1.5 m row spacings. * - 1.5 m rows significantly higher at 5% level.

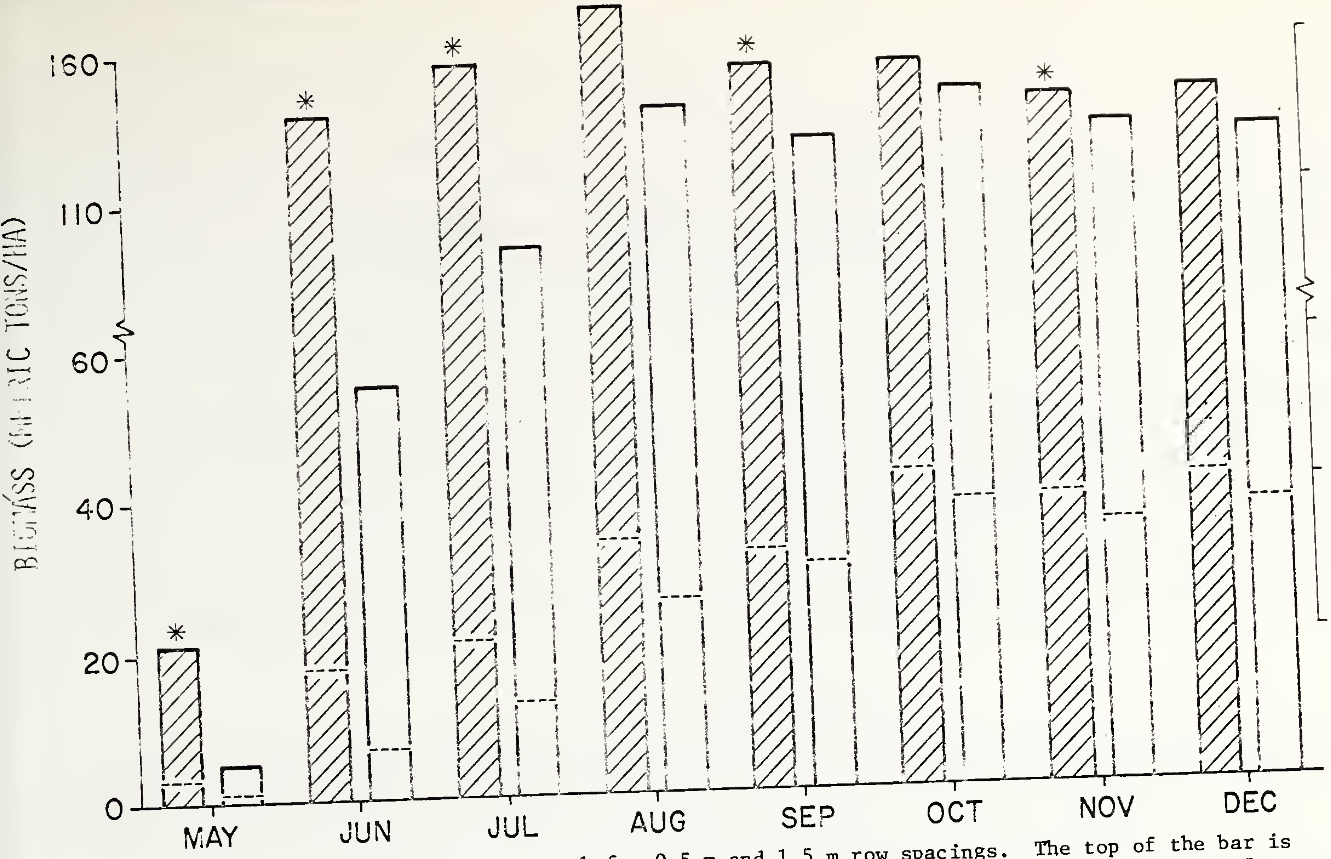

Figure 3. Above the ground biomass by month for 0.5 m and 1.5 m row spacings. The top of the bar is fresh weight and the lower portion is dry weight. Bars with diagonal lines are for 0.5 m rows and the unmarked bars are for 1.5 m rows. * - 0.5 m rows significantly higher at the 5% level.

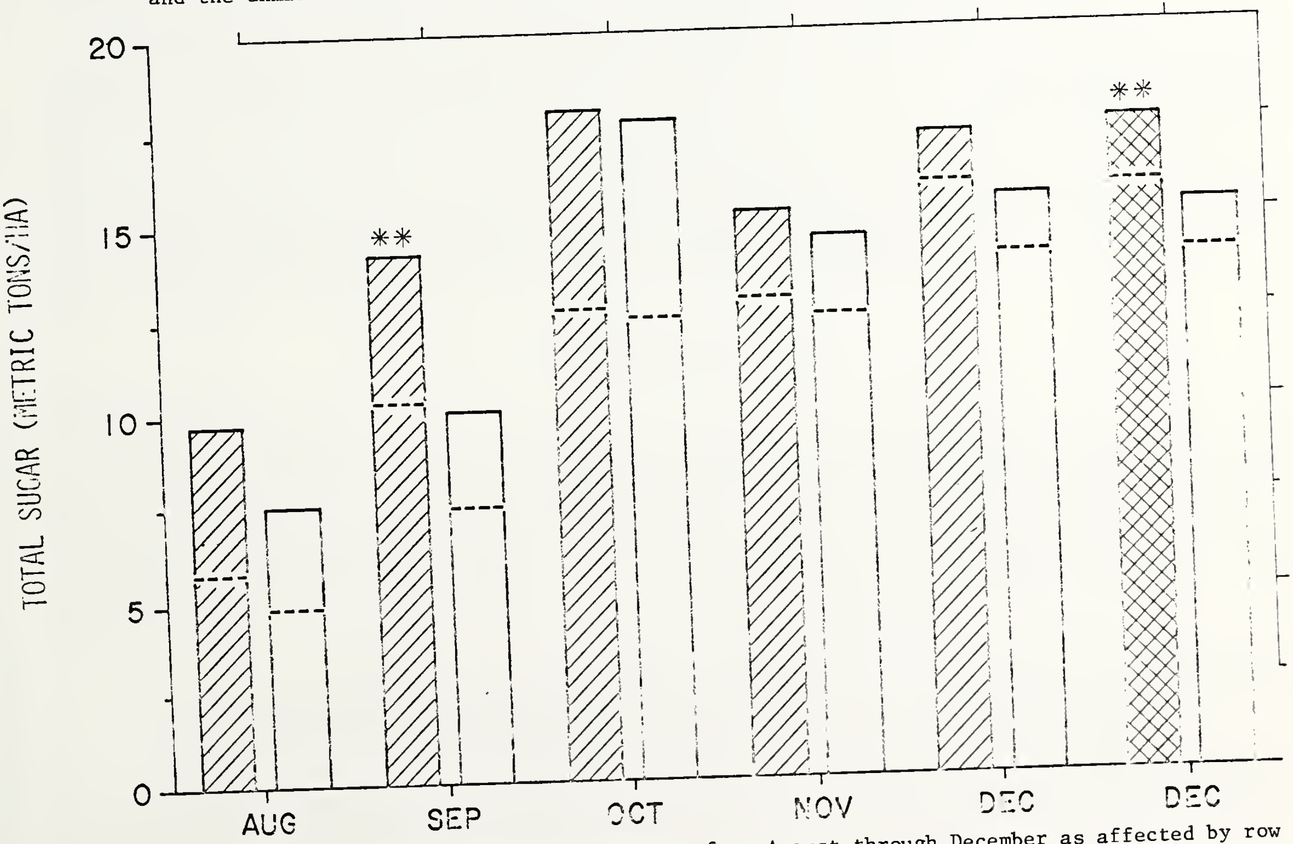

Figure 4. Total sugar and sucrose yields per hectare from August through December as affected by row spacing. The effect of glyphosine on total sugar and sucrose yields. Bars with diagonal lines are for 0.5 m rows and the unmarked bars are for 1.5 m rows. The bar with the cross-hatch lines is for the glyphosine plots. The tops of the bars denote total sugar in the biomass and the lower portions of the bars denote sucrose in the stalks. **-0.5 m rows and the glyphosine plots resulted in sugar and sucrose yields which were significantly higher, at the 1% level, than did the 1.5 m row and check plots, respectively.

Table 1. Total fiber in the above ground portion of sugarcane at two row spacings.

Month	0.5 M	1.5 M
	- - - - - - - - - - - Metric tons ha^{-1}	- - - - - - - - - - -
August	17.7	14.7
September	18.6	15.5
October	19.5	19.4
November	18.0	16.7
December	18.9	17.2

Differences between the row spacings were not significant at the 0.05 level by analysis of variance.

ACKNOWLEDGMENT

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SUGARCANE BIOMASS PRODUCTION AND NUTRIENT CONTENT AS RELATED TO CLIMATE IN FLORIDA[1]

S. F. Shih and G. J. Gascho
University of Florida, IFAS
Agricultural Research and Educational Center
Belle Glade, Florida

ABSTRACT

Sugarcane was grown at row spacings of 0.5 and 1.5 m at Belle Glade, Florida for biomass production. A regression model involving degree days and solar radiation was developed to predict monthly sugarcane biomass and total nutrient content. The dry weight was predicted well by either degree days, solar radiation, or a combination of degree days and solar radiation. The fresh weight and N, P, K, Ca, and Mg were predicted well only when the model combined both degree days and solar radiation. The ranges of multiple regression coefficients (R) for biomass and nutrient content predictions varied from 0.71 to 0.93 in the 0.5 m row spacing, from 0.83 to 0.97 in the 1.5 m row spacing, and from 0.7 to 0.92 when both row spacings were combined. Sugarcane biomass and nutrient content were accurately predicted by using both degree days and solar radiation.

INTRODUCTION

Recent studies have indicated the potential of sugarcane as a renewable source of energy (5). Since sugarcane produces more biomass per unit area and time than any other crop presently grown, it is the prime candidate for research into the potential of this source of energy. One of the most promising ways of increasing the biomass per unit area is to decrease row spacings. A strategy of flexible co-product manufacturing system has been considered for sugarcane production in which key biomass intermediates are processed either into fuels or materials, depending on relative price levels (6). In order to plan the harvesting schedule to accomplish the flexible component manufacturing system, a model to predict the potential yields of biomass and nutrient content needs to be developed.

Solar radiation and degree days have been used by Bourne (4), Allen (1), and Allen et. al. (2) to predict sugarcane yield. One unanswered question is whether the sugarcane yield is equally influenced by both solar radiation and degree days. Allen (1) combined total degree days together with average daily solar radiation. However, Bates (3) indicated that there are some inherent weaknesses in the degree-day concept and that solar radiation is a more accurate guide than degree days in crop production since solar radiation provides for both the photosynthesis and heat required in crop production. It is unknown whether the sugarcane biomass and total nutrient can be predicted based on either degree days, solar radiation alone, or combining both degree days and solar radiation. Therefore, the objectives of this study were: 1. to develop a general model based on degree days and solar radiation for predicting the monthly biomass and nutrient content in two row spacings, and 2. to predict the potential biomass production in Florida based on long term historical records of temperature and solar radiation.

MATERIALS AND METHODS

Sampling and Data Source

Sugarcane biomass was measured in a field located at the Agricultural Research and Education Center (AREC), Belle Glade, Florida. A narrow row spacing of 0.5 m was compared with the conventional row spacing of 1.5 m in four blocks of a randomized complete block design. Each plot was 33.5 x 24.4 m. Standard methods of pest control and fertilization were followed. The water table was maintained at a depth of approximately 45 cm below the soil surface. Cane variety 'CP 65-357' was planted in December, 1976. Due to the freezes of January and February, 1977, the young cane plants were frozen to ground level. Skips greater than 1 meter were replanted in March, 1977. All the cane grew well after replanting. The sample procedures were:

1. Biomass production was estimated monthly by harvesting 50 consecutive stalks of cane from each plot the first week of each month. The canes were cut at ground level from the interior of the plot. Both fresh and dry weights were obtained. Biomass was then calculated by obtaining the product of the number of stalks per hectare times the average weight per stalk.

2. Nutrient content was estimated monthly by analyzing a second 15 stalk sample. The sample was dried at 70 C and ground to 2 mm in a Wiley Mill and analyzed for N by the semi-microkjeldahl

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[1] Contribution from the Florida Agricultural Experiment Station as Journal Series No. 1646. This study was partially supported by the United States Department of Energy through a grant from Battelle Columbus Laboratories.

method, for P by the Molybdivanadophosphate method, and for K, Ca and Mg by atomic absorption. Total nutrient content was then calculated by obtaining the product of the biomass/hectare times the nutrient concentration.

Climatological data for this project were obtained from published records of the AREC, Belle Glade, Florida[3]. Solar radiaton was measured by the Eppley model 8-48 pyranometer and a Leeds and Northrup Speedomax H recorder with a Disc Instruments, Inc. model 207 R Integrator.

Solar radiation and temperature data were compiled for April through October to correspond with the Glades-area sugarcane grand growth period. Daily radiation was compiled and averaged for the years 1971 through 1977. The monthly average of daily solar radiation for 7 years and for 1977 are listed in Table 1. Degree days (DD) is defined as a daily mean temperature above 60 F (15.7 C). For example, a 80 F (26.7 C) average daily mean temperature = 20 degree days. Monthly degree days for a 52-year average (1926-1977), and for 1977 were also listed in Table 1. A 52-year average of degree days and/or 7-year average of solar radiation as shown in Table 1 were used to predict the potential sugarcane biomass production and nutrient contents in Florida. The data of 1977 alone were also used for 1977 biomass and nutrient content predictions.

Table 1. Monthly degree days and monthly average of daily solar radiation.

	Temperature				Solar radiation			
	52 year average (1926-77)		1977		7 year average (1971-77)		1977	
Month	MD_i*	CMD_i	MD_i	CMD_i	MR_i	CMR_i	MR_i	CMR_i
	- - - - - - degree days	- - - - - -			- - - - - - - - - - ly/dy	- - - - - - - -		
Apr.	324	324	359	359	514	514	517	517
May	459	783	462	821	501	1015	514	1031
June	550	1333	627	1448	474	1489	504	1535
July	629	1962	653	2101	457	1946	460	1995
Aug.	640	2602	664	2765	448	2394	443	2438
Sept.	596	3198	614	3379	405	2799	397	2835
Oct.	464	3662	390	3769	375	3174	415	3250

*MD_i = The degree days of ith month

CMD_i = Cumulative degree days at ith month

MR_i = The average of daily solar radiation in ith month

CMR_i = Cumulative average of daily solar radiation at ith month

Model Development

A hypothesis concerning the accumulation rate of biomass and nutrient as a function of degree days, solar radiation, and time was made to simulate the monthly sugarcane biomass and nutrient content. If the biomass accumulation by the end of a given month was proportional to the degree days (MD) and average daily solar radiation (MR) over that month, then the new biomass (B_i) accumulated over each month would be proportional to ($CMD_i + CMR_i$) or

$$B_1 \propto (CMD_1 + CMR_1)$$

$$B_2 \propto (CMD_2 + CMR_2)$$

$$- - - - - - - - - - \qquad 1)$$

$$B_n \propto (CMD_n + CMR_n)$$

where

$$CMD_1 = MD_1$$

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[3] A series of annual research reports published by AREC - Belle Glade.

$$\begin{aligned} CMD_2 &= CMD_1 + MD_2 \\ &\text{- - - - - - - - - -} \qquad \text{2)} \\ CMD_n &= CMD_{n-1} + MD_n \end{aligned}$$

and

$$\begin{aligned} CMR_1 &= MR_1 \\ CMR_2 &= CMR_1 + MR_2 \\ &\text{- - - - - - - - - -} \qquad \text{3)} \\ CMR_n &= CMR_{n-1} + MR_n \end{aligned}$$

the cumulative biomass, CB_i, would be

$$\begin{aligned} CB_1 &= B_1 \\ CB_2 &= CB_1 + B_2 \\ &\text{- - - - - - - - -} \qquad \text{4)} \\ CB_n &= CB_{n-1} + B_n \end{aligned}$$

The formulation of sugarcane nutrient content was similar to the biomass accumulation.

The model used to predict sugarcane biomass and nutrient content at ith month (BN_i) can be expressed as:

$$BN_i = a + b(CMD_i) + c(CMR_i) \qquad \text{5)}$$

where

BN_i = either biomass in T/ha, or total nutrient content in kg/ha at ith month;

CMD_i = cumulative degree days at ith month

CMR_i = cumulative average of daily solar radiation at ith month

a, b, c = constants

In order to observe the possibility of using either the CMD_i or the CMR_i variables alone to predict the biomass and nutrient content, equation 5 can be separated into two cases.

Case 1. For degree days variable alone:

$$BN_i = b_o + b_1\ (CMD_i) \qquad \text{6)}$$

Case 2. For solar radiation alone:

$$BN_i = c_o + c_1\ (CMR_i) \qquad \text{7)}$$

where b_o, b_1, c_o, and c_1 are constants.

RESULTS AND DISCUSSION

The cumulative degree days at ith month (CMD_i) and cumulative average of daily solar radiation at ith month (CMR_i) as defined in equations 2 and 3 were computed based on degree days and average daily solar radiation. The results for a 52 year average and for 1977 were presented in Table 1. The monthly data for fresh and dry weights, N, P, K, Ca, and Mg in 0.5 and 1.5 m row spacings are presented in Table 2. As Tables 1 and 2 show, the data on biomass and nutrient content (BN) had a 1-month lag as comparing with the data of degree days and solar radiation because the data of BN were sampled at the first week in each month. Therefore, a 1-month lag must be considered in equations 5, 6 and 7 for this study. For example, the data of CMD_4 and CMR_4 were used to predict the parameter BN_5. In order to overcome the row spacing effect, a case of combining both 0.5 and 1.5 row spacings (CNW) was also studied. Based on the data given in Tables 1 and 2, a regression analysis was used to estimate the regression coefficients (b_o, b_1, c_o, and c_1) as shown in equations 6 and 7, and correlation coefficients (r) for both narrow and wide row spacings. The results are listed in Table 3. Two observations can be drawn from Table 3. First, the CMR variable alone was slightly better than CMD alone because the r value was improved from 0 to 0.05. Second, either the CMD or the CMR variables can be used alone to predict the dry weight of biomass because the r values were 0.92 to 0.97. But, the predictions for other parameters were not shown to be good in both row spacings. Therefore, a model indicated in equation 5 was applied.

Table 2. Monthly sugarcane biomass, and nutrient content in two row spacings

Month	Row spacing	Fresh weight	Dry weight	N	P	K	Ca	Mg
	- m -	- - - T/ha	- - -	- - - -	- - -	kg/ha	- - -	- - -
May	0.5	21.15	3.13	55.45	10.13	115.68	10.40	5.40
	1.5	5.74	0.90	16.25	2.95	31.18	3.18	1.68
June	0.5	136.90	16.95	180.18	40.15	490.90	36.95	31.55
	1.5	57.56	7.11	84.20	15.13	218.80	15.18	12.98
July	0.5	153.40	21.18	167.60	36.20	421.85	54.95	38.95
	1.5	91.38	12.60	106.13	21.75	280.98	29.40	23.43
Aug.	0.5	170.66	34.29	196.20	39.48	548.55	48.93	39.38
	1.5	139.21	27.26	158.23	31.45	464.63	39.65	29.08
Sept.	0.5	149.50	35.83	160.65	31.93	394.18	33.43	28.18
	1.5	125.50	30.83	149.70	27.83	389.70	27.58	24.58
Oct.	0.5	151.25	40.28	200.25	38.50	439.25	47.00	38.00
	1.5	143.73	38.00	181.00	36.00	448.25	43.50	33.50
Nov.	0.5	127.36	35.53	184.50	41.10	342.75	45.50	38.90
	1.5	116.40	33.78	169.75	35.10	353.25	41.08	33.93

Table 3. Coefficients of regression and correlation for either cumulative degree days (CMD) or cumulative average of daily solar radiation (CMR) in two row spacings.

Parameters	Row spacing	CMD			CMR		
		b_o	b_1	r	c_o	c_1	r
	- -m - -						
Fresh weight	0.5	87.7548	0.0202	0.52	74.1433	0.0288	0.57
	1.5	28.9688	0.0326	0.84	12.5771	0.0436	0.85
	CNW*	58.3618	0.0264	0.64	43.3602	0.0362	0.67
Dry weight	0.5	6.7193	0.0096	0.92	2.1273	0.0127	0.93
	1.5	-1.1701	0.0108	0.96	-5.9738	0.0142	0.97
	CNW	2.7746	0.0102	0.92	-1.9233	0.0134	0.92
N	0.5	112.3684	0.0245	0.64	97.4077	0.0341	0.67
	1.5	36.0943	0.0418	0.92	15.3911	0.0558	0.93
	CNW	74.2314	0.0332	0.73	56.3994	0.0449	0.75
P	0.5	23.7393	0.0049	0.57	20.4814	0.0069	0.62
	1.5	6.2656	0.0086	0.93	1.9855	0.0115	0.94
	CNW	15.0025	0.0068	0.69	11.2334	0.0092	0.72
K	0.5	327.1156	0.0317	0.29	299.9558	0.0481	0.34
	1.5	118.4027	0.0927	0.79	70.7657	0.1245	0.81
	CNW	222.7592	0.0622	0.53	185.3608	0.0863	0.56
Ca	0.5	27.1060	0.0060	0.52	22.9786	0.0086	0.57
	1.5	7.4750	0.0101	0.87	2.3821	0.0135	0.89
	CNW	17.2905	0.0080	0.65	12.6804	0.0110	0.68
Mg	0.5	19.0872	0.0059	0.62	15.2533	0.0084	0.67
	1.5	5.4337	0.0083	0.91	1.2175	0.0111	0.93
	CNW	12.2604	0.0071	0.71	8.2354	0.0097	0.74

*CNW = Combining both 0.5 and 1.5 m row spacings data.

According to the data shown in Tables 1 and 2, a maximum multiple correlation coefficient (R) improvement stepwise multiple regression program was applied to estimate the coefficients given in equation 5. The results of a, b, c, R and F-test for 0.5 m row spacings, and CNW case were listed in Table 4. Some observations can be drawn from Table 4:

1. The multiple correlation coefficients(R) in Table 4 are higher than the correlation coefficients(r) given in Table 3. This implies that the multiple regression including both CMD and CMR is better than the linear regression with either the CMD or the CMR variable alone except in the case of dry weight.
2. The multiple regression as shown in equation 5 can be used to predict biomass and nutrient content because the F-test were all highly significant at the 0.01 level.
3. The ranges of multiple correlation coefficients varied from 0.71 to 0.93 in 0.5 m row spacing and from 0.83 to 0.97 in 1.5 m row spacing. The predictions in 1.5 m row spacing were better than in 0.5 m row spacing. This could be attributed to the low stalk density in wide row spacing and consequent inefficient absorption of solar energy during the initial growth period. The accumulation of greater biomass and nutrient content came later and more closely conformed with the best climatic conditions.
4. The range of multiple correlation coefficients in the CNW case varied from 0.7 to 0.92 which was very close to the range obtained in 0.5 m row spacing. This implied that the biomass and nutrient content can be predicted well when the row spacing is greater than 0.5 m.

Table 4. Coefficients of multiple regression and correlation and F-test in two row spacings.

Parameters	Row spacing	Multiple regression coefficients a	b	c	Multiple correlation coefficient (R)	F-test
	- m -					
Fresh weight	0.5	-62.7427	-0.3048	0.4279	0.81	**
	1.5	-29.7857	-0.0943	0.1671	0.87	**
	CNW	-46.2641	-0.1996	0.2975	0.76	**
Dry weight	0.5	-3.0208	-0.0115	0.0277	0.93	**
	1.5	0.9048	0.0153	-0.0059	0.97	**
	CNW	-1.0580	0.0019	0.0109	0.92	**
N	0.5	-19.1779	-0.2596	0.3741	0.84	**
	1.5	-27.4633	-0.0954	0.1807	0.95	**
	CNW	-23.3206	-0.1775	0.2774	0.81	**
P	0.5	-11.7880	-0.0719	0.1010	0.88	**
	1.5	-7.1784	-0.0204	0.0382	0.96	**
	CNW	-9.4832	-0.0461	0.0696	0.80	**
K	0.5	-102.5739	-0.8964	1.2218	0.71	**
	1.5	-80.3426	-0.3365	0.5651	0.83	**
	CNW	-91.4582	-0.6165	0.8935	0.70	**
Ca	0.5	-20.8871	-0.0977	0.1365	0.85	**
	1.5	-11.6734	-0.0313	0.0545	0.91	**
	CNW	-16.2802	-0.0645	0.0955	0.78	**
Mg	0.5	-19.8478	-0.0782	0.1107	0.90	**
	1.5	-11.1844	-0.0276	0.0473	0.96	**
	CNW	-15.5161	-0.0529	0.0790	0.84	**

CNW = Combining both 0.5 and 1.5 m row spacings data.
** = F-test significant at 0.01 level.

In an attempt to determine the potential sugarcane biomass and nutrient content that can be produced based on long term historical records of degree days and solar radiation, the results of long term prediction were close to the values obtained in 1977 (Table 5).

In order to observe the deviation between experimental data and predicted results, both experimental data and predictions based on equation 5 were plotted in Fig. 1 for biomass, and in Fig. 2 for nutrient content. A combined case without considering the row spacing difference was also plotted in Fig. 1. The high R value of 0.92 implies that the monthly sugarcane dry weight can be predicted well in both row spacings. These two figures show that the prediction model fits the experimental data very well and should be useful for biomass and nutrient content estimates.

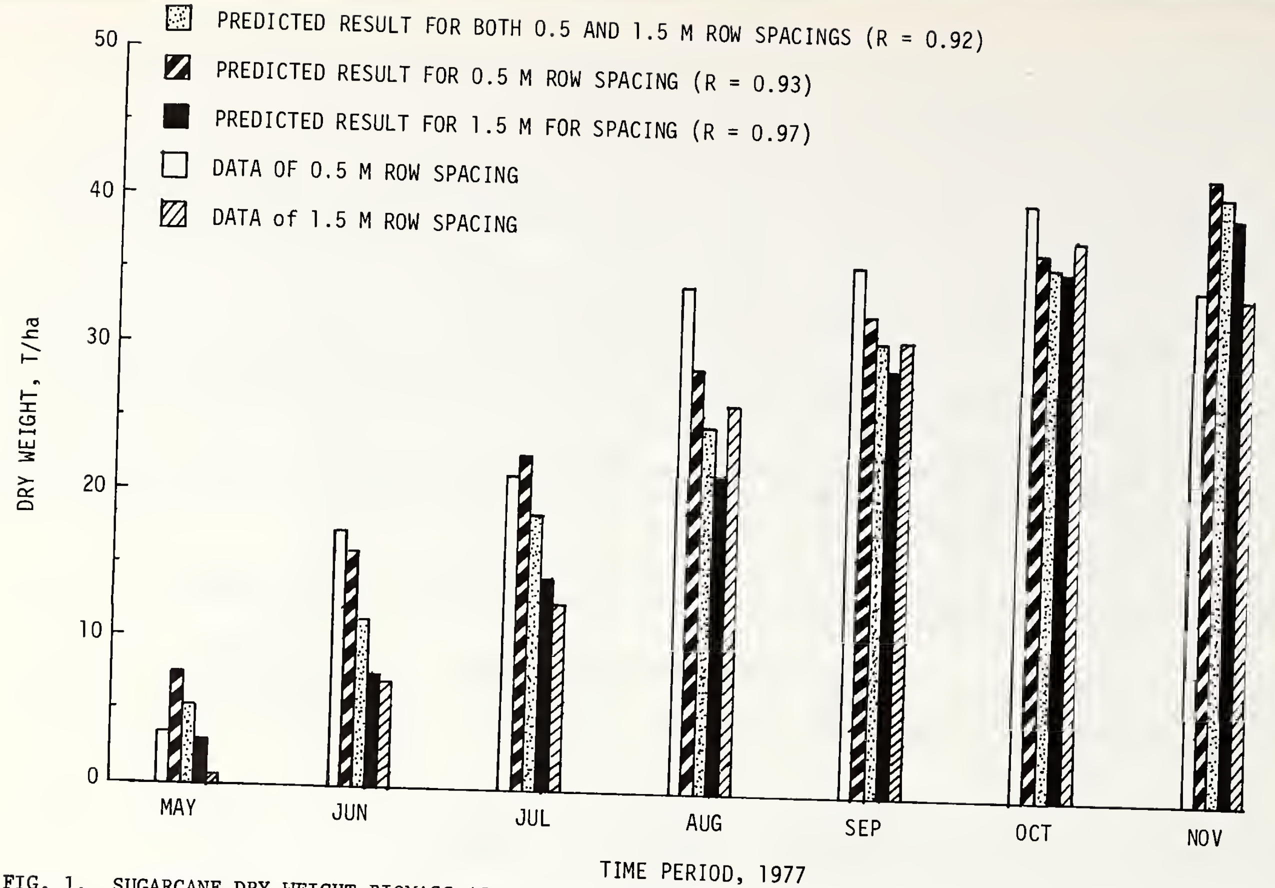

FIG. 1. SUGARCANE DRY WEIGHT BIOMASS AS RELATED TO DEGREE DAYS AND SOLAR RADIATION IN TWO ROW SPACINGS.

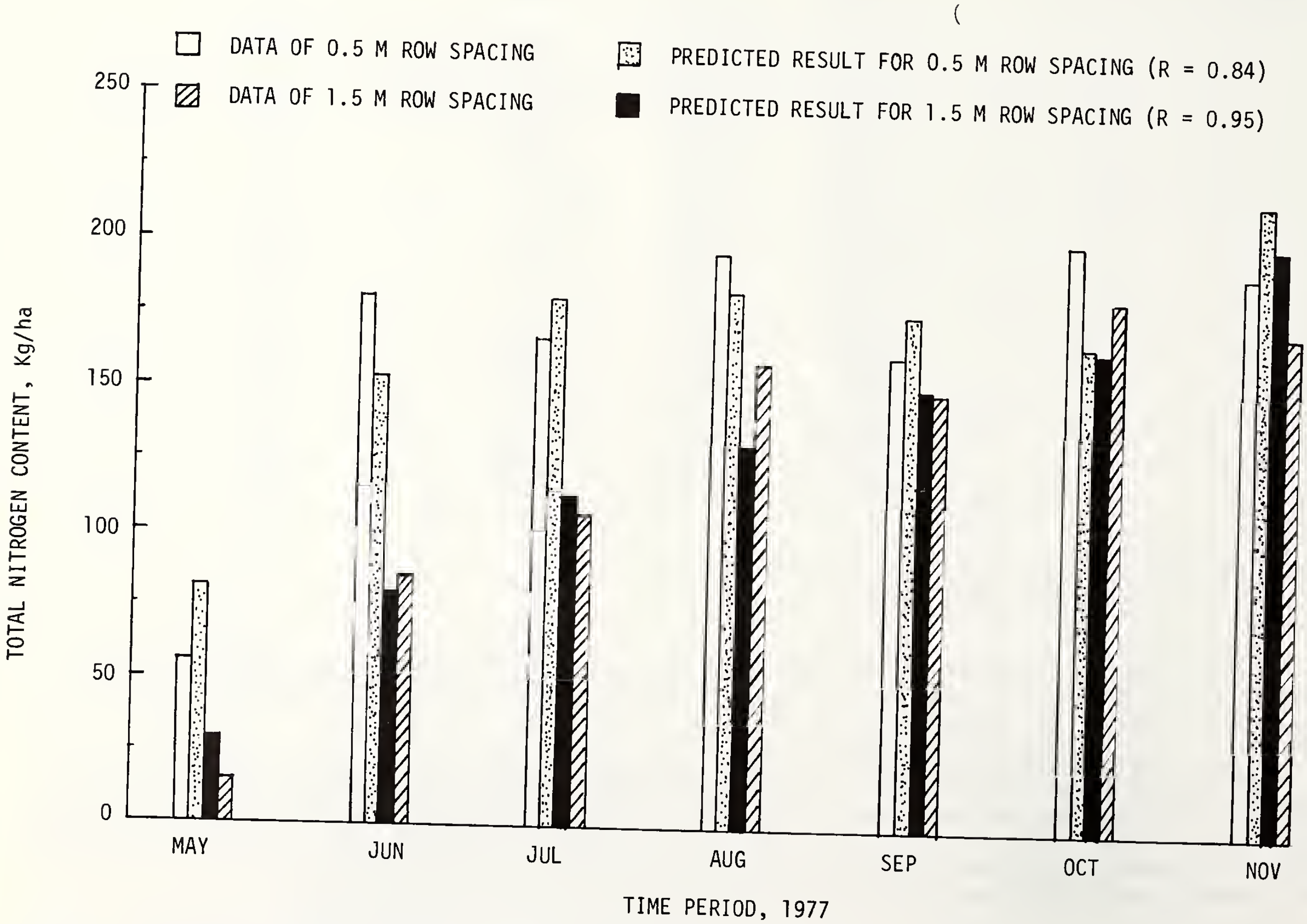

FIG. 2. SUGARCANE NITROGEN CONTENT AS RELATED TO DEGREE DAYS AND SOLAR RADIATION IN TWO ROW SPACINGS.

Table 5. Simulated results of the year 1977 and the long term average (1926-77) condition.

Month	Row Spacing	Dry wt.		N		P		K		Ca		Mg	
		1977	Lp[a]	1977	Lp	1977	Lp	1977	Lp	1977	Lp	1977	Lp
	- m -	- - -	- - -	- - -	- - -	- - -	- -	kg/ha	- - -	- - -	- - -	- - -	- - -
May	0.5	7.7	7.5	81.0	89.0	14.6	16.8	207.3	235.0	14.6	17.6	9.3	11.7
	1.5	3.3	2.8	31.7	34.5	5.2	5.8	91.0	101.1	5.3	6.2	3.4	4.2
	CNW[b]	5.3	5.2	56.4	61.8	10.0	11.4	149.2	168.1	9.9	11.9	6.3	8.0
June	0.5	16.1	16.1	153.4	157.3	33.3	34.4	421.2	435.7	39.6	41.2	30.1	31.3
	1.5	7.4	6.9	80.5	81.2	15.5	15.6	226.0	229.8	18.8	19.1	14.9	15.2
	CNW	11.7	11.5	117.0	119.3	24.4	25.1	323.7	332.7	29.2	30.1	22.5	23.2
July	0.5	22.8	22.9	179.2	191.8	39.1	42.8	474.9	521.8	47.2	52.1	36.8	40.7
	1.5	14.0	12.5	111.8	114.4	21.9	22.5	299.8	312.5	26.7	27.8	21.5	22.5
	CNW	18.4	17.7	145.5	153.1	30.6	32.7	387.4	417.2	36.9	39.9	29.1	31.6
Aug.	0.5	28.1	28.3	181.2	199.5	38.6	43.7	451.6	516.3	46.2	53.1	36.7	42.1
	1.5	21.3	19.4	132.6	137.0	26.2	27.1	340.0	359.1	31.3	33.0	25.2	26.7
	CNW	24.7	23.9	157.2	168.2	32.5	35.5	395.8	437.7	38.7	43.0	30.9	34.4
Sept.	0.5	32.8	33.4	175.1	200.9	35.6	42.9	397.6	490.0	41.8	51.7	33.8	41.7
	1.5	28.8	26.6	149.3	156.9	29.5	31.2	366.9	396.9	34.7	37.4	27.8	30.2
	CNW	30.8	30.0	162.2	178.9	32.7	37.2	382.3	443.4	38.2	44.5	30.8	36.0
Oct.	0.5	36.6	37.7	164.2	197.7	31.6	41.0	332.3	450.6	36.0	48.7	29.7	39.9
	1.5	35.9	33.3	162.5	173.2	32.2	34.5	384.7	425.2	37.1	40.8	29.7	32.9
	CNW	36.3	35.5	163.3	185.5	32.1	37.9	358.5	437.9	36.5	44.8	29.7	36.4
Nov.	0.5	43.7	42.8	218.2	217.6	45.5	45.5	489.7	492.8	54.5	54.6	45.2	45.1
	1.5	39.4	38.2	200.2	196.7	40.1	39.4	488.0	481.0	47.5	46.7	38.5	37.9
	CNW	41.5	40.5	185.9	207.1	43.0	42.6	488.8	486.9	51.0	50.6	41.9	41.5

[a] Lp = Long term prediction.

[b] CNW = Combining both 0.5 and 1.5 m row spacings data.

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MECHANICAL HARVESTING OF SWEET SORGHUM

J. H. Ruff, R. C. Dillon, Jr., and C. G. Coble
Assistant Professor, Agricultural Engineering Department, Texas A&M University
Research Agricultural Engineer, Texas Agricultural Experiment Station, Weslaco, Texas
Associate Professor, Agricultural Engineering Department Texas A&M University, College Station, Texas

ABSTRACT

Sweet sorghum has the potential of becoming either a sugar or biomass crop for the Rio Grande Valley of Texas. Efficient utilization of the crop for sugar requires the removal of large amounts of green, leafy trash. This paper reports on several research approaches to the mechanical harvesting of sweet sorghum that have been conducted by the Texas Agricultural Experiment Station. Included in the report are: the effects of storage duration and billet length upon sugar recovery; the use of conventional sugar cane harvesters for sweet sorghum harvesting; and field leaf stripping of sweet sorghum.

INTRODUCTION

Sweet sorghum has the potential of becoming either a sugar crop or a biomass (energy) crop. For either use sweet sorghum would interface well with present vegetable and sugarcane production systems in South Texas. A crop rotation of winter vegetables followed by sweet sorghum in the summer months would increase land utilization in the Lower Rio Grande Valley. Sweet sorghum would also extend sugarcane milling operations as the short growing season of sweet sorghum enables scheduling of maturity at an optimal time.

Harvesting systems must be developed before large-scale production of sweet sorghum becomes feasible. If sweet sorghum is utilized as a supplementary crop for sugarcane, conventional sugarcane harvesters are the obvious choice for sweet sorghum harvesting as an important need in both sugarcane and sweet sorghum harvesting is the reduction of green leafy trash material. In addition, dual usage of these machines would spread the annual fixed harvesting costs.

Several differences between sugarcane and sweet sorghum must be evaluated as to their effect upon machine performance. The large volume of dry leafy trash found in sugarcane is reduced by preharvest burning. Sweet sorghum has a large quantity of high moisture material and this prevents burning as a harvesting aid. The different aerodynamic properties between the sugarcane billet and the leafy material makes pneumatic cleaning the predominant method of trash reduction on sugarcane harvesters. Sweet sorghum billets are smaller in diameter and lighter than sugarcane billets and the leaves on sweet sorghum are wrapped tightly around the stalk. Thus, pneumatic separation of leafy trash from sweet sorghum billets may not be feasible.

Because of the great difference in yield between sugarcane and sweet sorghum, the capacity and ground speed of a sugarcane harvester must also be considered if it is used for sweet sorghum. Equivalent harvesting capabilities in the two crops can be obtained by increasing either the cutting width of the harvester or its ground speed in sweet sorghum.

Forage harvesters are another option that should be considered for sweet sorghum and their use in large-scale production needs to be evaluated. Wright et al., (1977) modified a forage harvester for sorghum syrup production, however, the machine capacity of 0.4 kg/s (1.5 tons/hr) is approximately one-third of one percent of the sugar mill capacity in the Rio Grande Valley. Another possible limitation of forage harvesters in large-scale sugar production systems is the maximum attainable billet length. Broadhead (1972) conducted a study on sweet sorghum to determine the effect of billet length upon leaf removal and sugar losses. That study was inconclusive as the results indicated that sugar losses were significantly greater for the shorter billet lengths compared to whole stalks but the sugar losses were economically unimportant.

The ultimate objective of this research is to develop a harvesting system for sweet sorghum. Research to achieve this objective has emphasized three major areas; 1) determination of crop properties relevant to machinery systems design, 2) field stripping of sweet sorghum, and 3) evaluation of sugarcane harvesters in sweet sorghum.

MATERIALS AND METHODS

Crop Properties Research

Aerodynamic tests were conducted on sweet sorghum billets as the initial step in the evaluation and design of pneumatic cleaning systems. Critical velocities of billets were determined by placing single billets on a screen in a vertically oriented plexiglass cylinder (0.61 meters in diameter). Air velocity was slowly increased in the duct until the billets started to float. A total of 412 billets of various diameters and three lengths (18, 33 and 43 cm) were tested.

A possible harvesting system for sweet sorghum could utilize a harvester similar to forage harvesters. In this system the material would be chopped into billets not exceeding 0.1 meters in length. The greater exposed cutting area of the short billets may be detrimental as rapid sugar inversion could occur. Thus, a study was conducted to evaluate the effect of billet length and storage duration upon sugar recovery.

Sweet sorghum which had been hand stripped the previous day was harvested and chopped into billets of three different length categories. Average billet lengths in these three categories were 0.12, 0.22, and 0.32 meters (4.7, 8.7, and 12.6 inches). A fourth length category was wholestalk sweet sorghum. Samples of each of the four length categories were subdivided into 90 kg (200 pound) samples and then stored for different time periods before being milled. One 90 kg sample of each length category was milled immediately after chopping while the other samples were milled approximately 4, 12 and 24 hours after chopping.

The sweet sorghum sugar loss study was conducted three times throughout the 1976 harvest season with a different variety being used for each test. The first test used sweet sorghum of the Rio variety. The second test was conducted two weeks later with Ramada sweet sorghum. Roma sweet sorghum was used for the third test that was conducted one week later.

Field Stripping of Sweet Sorghum

Sweet sorghum has a large quantity of green leafy material that eliminates preharvest burning as a harvesting aid. Since sweet sorghum is erect at maturity, the potential exists for reducing the leafy trash by a stripping or mowing operation before cutting the stalks. To test this cleaning concept two prototype leaf stripping units were designed and tested.

The first machine, illustrated in Figure 1, was single-row leaf mower that was constructed to straddle the row. As the unit moved along the row, high-speed mower blades located on both sides of the row created an aerodynamic suction and pulled the sorghum leaves into the vertical mowing planes.

Three 0.61 m (2 feet) diameter mower blades powered by hydraulic motors were positioned on each side of the row. Stalk restraining rods were positioned approximately 1 cm (0.5 inch) inwardly from the blades to prevent stalks from entering the cutting plane. Four chains with flights spaced every 10 cm (4.5 inches) along the chain moved at a zero velocity relative to the ground and aided the cane flow into the cutting region. The entire unit was side-mounted onto the chassis of a hydrostatic drive unit. Hydraulic cylinders controlled both the height of the mowing unit and the distance between the mower blades and the sorghum row.

The second experimental leaf stripper is illustrated in Figure 2. This unit was designed to remove the sweet sorghum leaves by a downward stripping action. The stripping fingers consisted of double spring fingers similar to the type used on pick-up headers on hay balers. The drive mechanism of the prototype unit was designed to give a downward finger velocity of 2.9 m/s (9.5 ft/s) and a zero horizontal velocity relative to the sweet sorghum stalks when the unit was traveling at a forward speed of 1.34 m/s (3.0 mph). Two belt-chains were mounted so as to sandwich the sorghum tops and hold the stalk erect as it was being stripped.

Sugarcane Harvester Evaluation in Sweet Sorghum

The use of sweet sorghum as a supplemental crop for sugarcane in the Lower Rio Grande Valley has the advantage of spreading annual fixed mill costs. If sugarcane harvesters could also be used for sweet sorghum, their annual fixed costs would also be spread. Their use would also eliminate the need for a separate machinery system for sweet sorghum harvesting. Thus, a study was conducted to evaluate the performance of sugarcane harvesters in sweet sorghum.

During the summer of 1975, harvesting tests were conducted with a Massey Ferguson 201 and a Toft 300 sugarcane harvester. Field losses and trash contents were determined at different extractor speeds by harvesting adjacent rows with the extractors off. The losses were determined from the difference in material weights between the adjacent rows after adjusting the weight for trash contents. These machines harvested one row of sweet sorghum at a time at an average ground speed of 1.23 m/s (2.75 mph). With this ground speed, the harvesting rate was approximately 4.6 kg/s (18 tons/hour).

Several sweet sorghum harvesting tests were conducted during the summer of 1977 with a Class sugarcane harvester. The crop dividers on the harvester were adjusted so as to harvest two 1.01 m (40 inch) rows. A ground speed of 1.11 m/s (2.5 mph) resulted in a harvesting rate of approximately 6.2 kg/s (25 tons/hour). Front end losses, primary blower losses, and trash percentages were measured and recorded for various primary and secondary cleaner velocities.

Besides the limitations of sugarcane harvesters in the cleaning of sweet sorghum there are two other inherent problems. First, these machines cannot harvest sweet sorghum at an economical rate because of the lower yield of sweet sorghum compared to sugarcane. Sugarcane averages approximately 9.0 kg/m^2 (40 tons/acre) in South Texas while sweet sorghum yields of 3.0 kg/m^2. The crop should be planted in 1.01 m (40 inch) rows. Sugarcane harvesters are designed for row spacings of at least 1.52 m (60 inches). Operating them in narrow rows produces excessive field losses because the harvesters tramples down the sweet sorghum in the next unharvested row.

Research was conducted on a Toft 300 sugarcane harvester in an effort to overcome these two limitations. A three-row forage harvester header (Hesston Field Queen) was mounted on the harvester as illustrated in Figures 3 and 4. A double chain feed conveyor was constructed and added to the harvester to convey the material from the header into the chopper feed rolls of the harvester. Hydraulic power was supplied to the header and the feed conveyor from the circuits that normally drive the crop dividers and topper.

RESULTS AND DISCUSSION

Crop Properties Research

The data obtained from the aerodynamic tests on sweet sorghum billets is plotted in Figure 5. Billets were classified into diameter categories (1/16th inch increments) and statistical analysis was used to find the mean and standard deviation for each size category. Linear regression analysis was used to develop the linear equation.

$$V_c = 6.41 + 4.89d \qquad (1)$$

where V_c is the critical velocity (m/s), and d is the billet diameter (cm). The regression equation and its 5% confidence limits are plotted in Figure 6.

The results of the aerodynamic tests have several implications in regard to pneumatic cleaning of sugarcane. The dependence of the critical velocity upon billet diameter is not desirable for optimum pneumatic cleaning. High air velocities for effective cleaning will cause excessive losses of the smaller billets. Clayton (1973) and León (1974) reported that the critical velocities of sugarcane billets were in the 20 to 30 m/sec range. Since the critical velocities of sweet sorghum billets are much lower it appears probable that pneumatic cleaning will not be as effective in sweet sorghum.

Data obtained from the chopper length and storage duration study is listed in Tables 1, 2, and 3. No statistical analysis was used on the data for several reasons. The sweet sorghum samples milled at the 4 hour storage duration were hand-stripped so that these juice samples were from trash-free material. In addition, because of the extensive manpower requirements for harvesting, chopping, transporting, and milling the sweet sorghum it was not possible to use replications.

Several important trends are evident by the results listed in the tables. Table 1 indicates that neither the billet length or the storage time had an effect upon brix. Similar, Table 2 shows that the billet length had an effect upon pol. A relationship between pol and storage time is indicated by the data listed in Table 2. The average pol decreased as the storage time increased except for the 4 hour storage time. This exception can probably be explained by the fact that these were trash-free samples.

Table 3 contains the purity data for various billet lengths and storage durations. An important trend is the decrease in purity with storage time. The average purity for no storage time was 70.5% while it decreased to 67.5% and 63.0% for the 12 and 24 hour storage times, respectively. Once again, the 4 hour samples (trash-free material) is an exception to this trend.

Field Stripping of Sweet Sorghum

The leaf mower unit was tested in Rio sweet sorghum in 1976. The sweet sorghum tested had an initial leaf trash content of 25 percent with the condition of the leaves being dry. In these field conditions, the mower blades were able to remove 54 percent of the total leaf material. Thus, the mowing operation lowered the total trash content from 35 percent to 22 percent. Ground speed in these tests was fixed at 1.4 miles per hour.

The leaf stripping unit was also tested in Rio sweet sorghum. This unit was first tested without a device to hold the tops of the sweet sorghum tops. Losses over 50% were recorded with this arrangement as the stripper fingers pulled stalks downward and broke them. After the stalk holding belts were installed, damage was reduced to 7%. Operation of this unit in sweet sorghum at a speed of 1.34 m/s (3mph) removed 58% of the leaves.

Sugarcane Harvester Evaluation in Sweet Sorghum

Table 4 summarizes the sweet sorghum harvesting tests with three commercial sugarcane harvesters, a Massey Ferguson 201, a Toft 300 and a Claas harvester. Trash percentage ranged from a low of 12.5% with

Table 1. Brix of sweet sorghum billets that were chopped in different lengths and stored for different time durations. Four hour juice samples were from detrashed material.

Length (cm)	Storage Times (Hrs)				Average
	0	4	12	24	
12	15.4	15.7	14.8	14.9	15.2
22	15.0	15.9	14.8	14.8	15.1
32	14.7	14.8	14.5	14.6	14.6
Wholestalk	14.7	14.8	15.1	15.6	15.0
Average	14.9	15.3	14.8	15.0	15.0

Table 2. Pol of sweet sorghum billets that were chopped in different lengths and stored for different time durations. Four hour juice samples were from detrashed material.

Length (cm)	Storage Times (Hrs)				Average
	0	4	12	24	
12	10.9	11.1	9.9	9.1	10.3
22	10.4	11.5	10.1	9.5	10.4
32	10.4	10.9	9.8	9.4	10.1
Wholestalk	10.5	10.7	10.3	9.9	10.4
Average	10.6	11.0	10.0	9.5	10.3

Table 3. Purity of sweet sorghum billets that were chopped in different lengths and stored for different time durations. Four hour juice samples were from detrashed material.

Length (cm)	Storage Times (Hrs)				Average
	0	4	12	24	
12	70.7	70.3	66.8	60.3	67.0
22	69.5	72.3	67.9	63.8	68.4
32	70.8	73.2	67.3	64.2	68.9
Wholestalk	71.1	71.9	68.1	63.6	68.7
Average	70.5	71.0	67.5	63.0	68.2

Table 4. Sweet sorghum harvesting data summary for sugarcane harvesters.

Harvester	Average Capacity (kg/sec)	Percent Trash	Percent Billet Loss
Massey Ferguson 201[1]	4.6	12.5	38.5
Toft 300[2]	3.8	22.9	10.3
Claas[3]	6.2	20.3	16.7

[1] Average of four harvesting tests, 1975.

[2] Average of seven harvesting tests, 1975.

[3] Average of six harvesting tests, 1977.

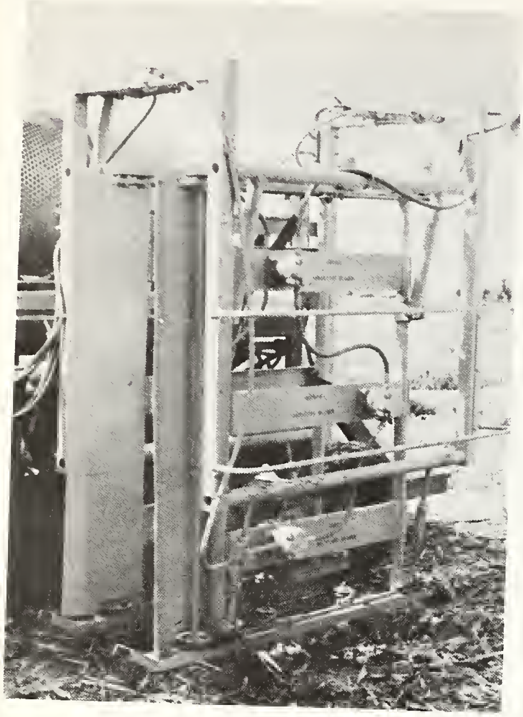

Figure 1. Sweet sorghum leaf mower unit.

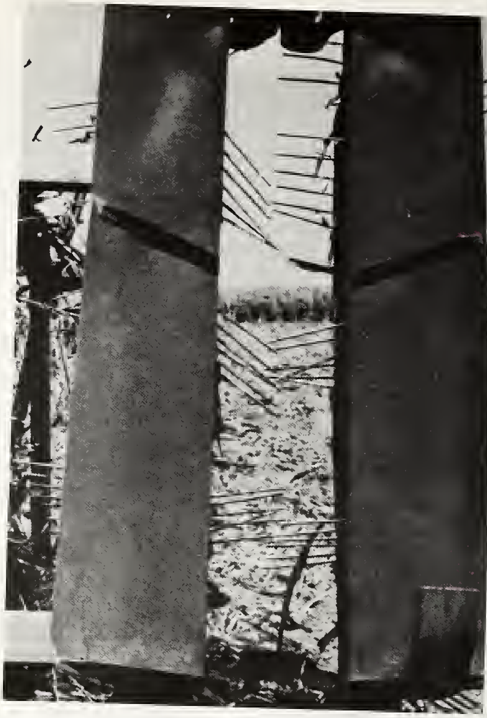

Figure 2. Sweet sorghum leaf stripper unit

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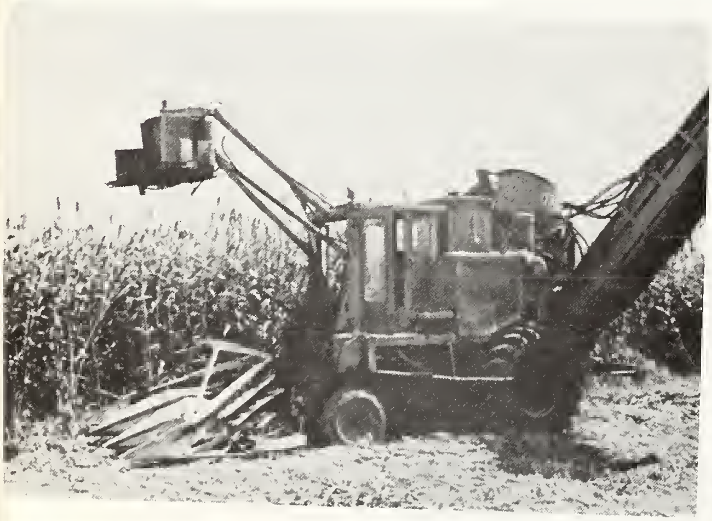

Figure 3. Side view of Toft 300 sugarcane harvester with three-row corn header.

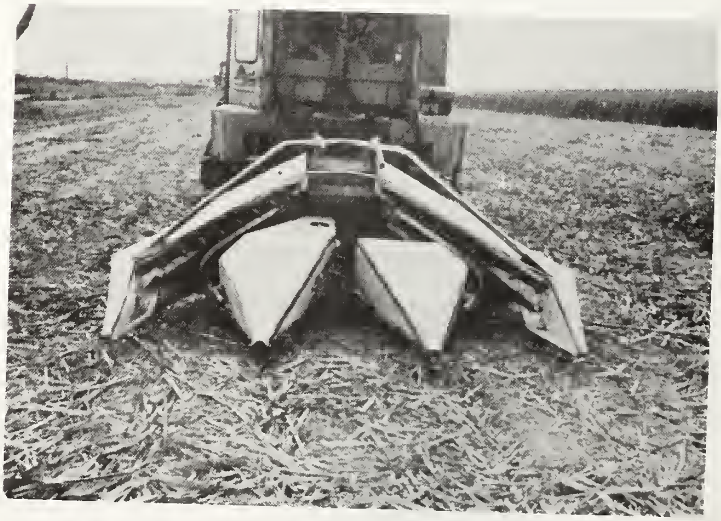

Figure 4. Three-row corn header on Toft 300 sugarcane harvester.

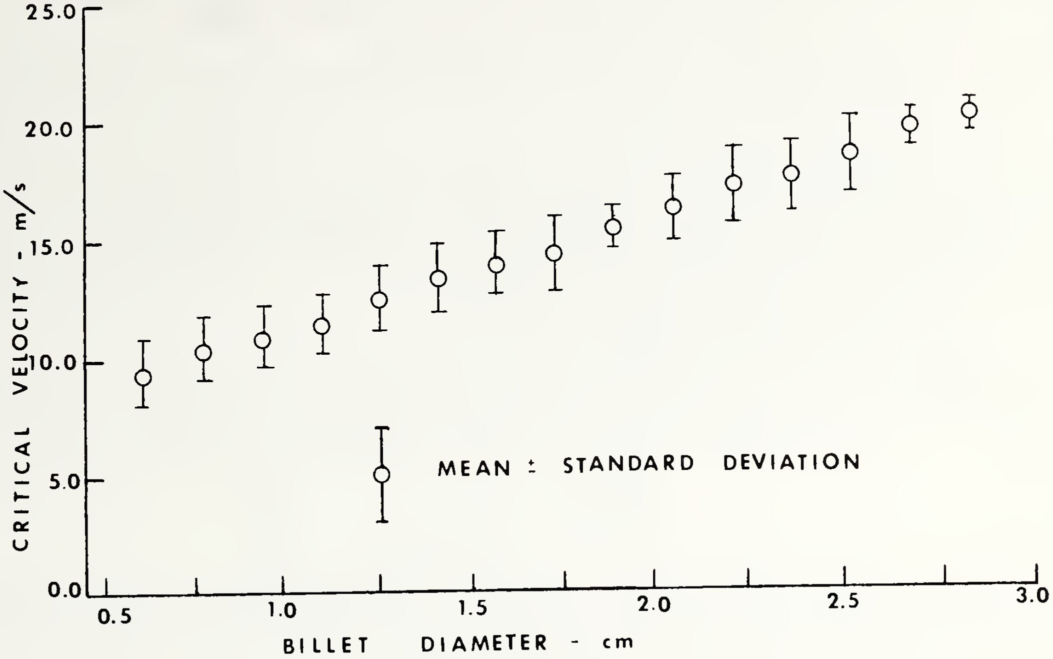

Figure 5. Mean and standard deviation for critical velocities of sweet sorghum billets.

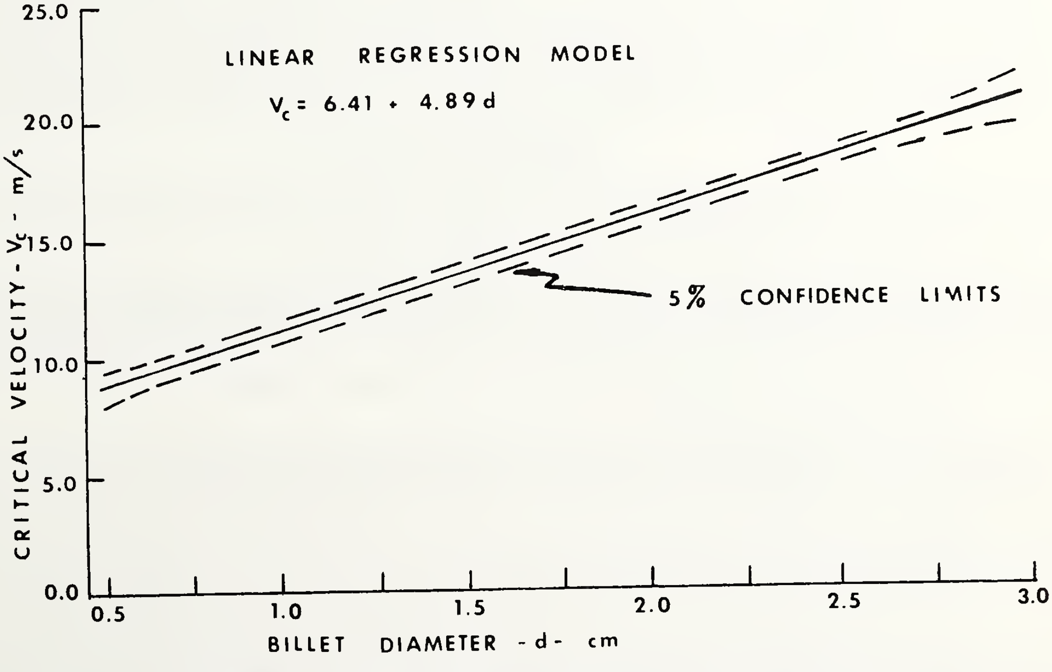

Figure 6. Linear regression model of critical velocities of sweet sorghum billets.

the Massey Ferguson machine to a high of 22.9% with the Toft 300. Billet losses were reversed; however, the Massey Ferguson had the highest loss of 38.5% while the Toft 300 had the lowest of 10.3%. The Claas harvester was intermediate in performance for both trash and billet loss even though it operated at a higher capacity than the other two machines.

Table 4 is important not to its ranking of harvesters but in its quantitative description of the problems associated with pneumatic cleaning of sweet sorghum. Trash levels and billet losses are excessive for all three harvesters. In addition, a reduction in trash requires a sacrifice in billets.

Table 5 lists the trash percentages obtained from operating the Claas harvester in sweet sorghum. Both the primary blower air velocity and the secondary extractor air velocity were varied in order to determine their relative effects upon trash reduction. The primary blower appears to have more effect upon cleaning than the secondary extractor fan. Only at a primary blower velocity of 27.9 meters per second did the addition of the secondary extractor have a significant effect upon trash reduction. An increase in the primary blower air velocity from 32.0 to 34.5 meters per second had a significant effect upon trash reduction for both secondary velocities.

Table 5. Percent trash in sweet sorghum harvested by Claas sugarcane harvester. Two rows harvested at an average rate of 6.2 kg/sec.

Primary Cleaner Velocity (m/sec.)	Secondary Extractor Velocity (m/sec.)		
	0	16.3	Average
27.9	24.8^{ab}	19.0^{b}	21.9
32.0	25.1^{ab}	23.0^{b}	24.0
34.5	14.5^{c}	15.4^{c}	14.9
Average	21.5	19.1	20.3

Numbers followed by the same letter are not significantly different at the 1% level

Separate field harvesting studies were conducted with the Toft 300 that had been modified by the addition of a three-row corn header. Approximately 2.5 hectares (6 acres) of sweet sorghum was harvested with this unit. Steering control problems resulting from having to operate the steering wheels on the edge of the beds prevented operation of the harvester at greater speeds. Average harvesting capacity of the machine was 7.4 kg/sec. (29.5 tons/hour). The harvested sweet sorghum had an average trash level of 39.1%. The modification was very successful in increasing the capacity of the harvesters in sweet sorghum. The in-feeding system was very aggressive and was not a problem. Field losses were practically non-existent except for the cleaning losses. Although data was not collected upon the cleaning performance of the modified harvester, it appeared that trash removal would be more of a problem at the higher material flow rates.

SUMMARY AND CONCLUSIONS

Sweet sorghum harvesting research has been directed towards 1) obtaining crop properties data that is relevant to harvesting system design, 2) evaluating the potential of leaf stripping of sweet sorghum, and 3) evaluation of sugarcane harvester performance in sweet sorghum.

Aerodynamic tests on sweet sorghum quantitatively defined the critical velocity range of sweet sorghum billets. The critical velocity range for sweet sorghum billets is approximately one-half the range for sugarcane billets. Thus, pneumatic cleaning of sweet sorghum will not be as efficient as it is for sugarcane.

Sugar quality studies indicated that both the pol and purity of sweet sorghum decreased as the storage duration of chopped billets increased.

Field stripping units reduced leaf trash on standing sweet sorghum by more than 50%. Although the trash reduction is very significant, pneumatic cleaning might be just as effective because of the leafy nature of the trash. These one-row prototype units need to have greater capacity for a large-scale production system.

Three commercial sugarcane harvesters were tested in sweet sorghum. Although field losses through the pneumatic cleaning systems were excessive trash levels were still not acceptable. A three-row corn header was incorporated onto a sugarcane harvester in an attempt to increase its material capacity. Mechanically, the concept appears very feasible but the increased capacity increases the sweet sorghum cleaning problem.

Sweet sorghum harvesting system research is a necessity before large-scale production of the crop becomes feasible. If the crop is used for sugar, cleaning is the major problem that must be solved.

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ECONOMIC ASPECTS OF SUPPLYING SUGARCANE AND SWEET SORGHUM AS RENEWABLE RESOURCES FOR FUELS PRODUCTION

T. A. McClure
Battelle-Columbus Division
Columbus, Ohio

ABSTRACT

Estimated costs of producing and harvesting close-spaced sugarcane and sweet sorghum are presented, and major changes in input requirements and costs from conventional production practices are noted. Close spacing appears to have potential for reducing per-kilogram costs of fermentable sugars and fiber useful for fuel or chemical production. The cost of fermentable sugars as energy feedstocks is affected by the extent to which the fibrous portion of the plant can be upgraded into higher-value products, such as fiberboard and paperboard, through the use of new processing techniques. Prospects for additional sugarcane biomass production on new lands are examined, including land availability and crop land development activities and costs. Prospective 1978 costs and returns on newly developed land for sugarcane production are presented. Potential sugarcane or sweet sorghum grower income under alternative ethanol price levels is estimated. Comparisons between the two crops are noted, along with the potential income from alternative crops, such as corn, soybeans and cotton.

INTRODUCTION

There have been many excellent papers presented today on the agronomic and mechanical aspects of producing sugar crops for biomass. My presentation indicates some of the technical-economic factors affecting sugarcane and sweet sorghum as renewable resources for energy or chemicals production. This paper summarizes the results of a portion of the overall Battelle study for the U.S. Department of Energy on fuels from sugar crops.* Included is a brief discussion of

New cropland development for sugarcane

Cropland development costs

Costs of close spacing sugarcane and sweet sorghum

Comparisons of grower income from biomass crops with conventional crop production

Energy input requirements for producing, harvesting, and transporting close-spaced sugarcane and sweet sorghum

Theoretical "contained energy" in sugarcane and sweet sorghum.

NEW CROPLAND DEVELOPMENT

One factor to be considered in evaluating any renewable resource as a candidate for biomass production is the crop's geographic range. In this respect, sweet sorghum compares favorably to sugarcane in that it can be produced in most areas in which corn can be grown. Sweet sorghum requires a shorter growing season and is adaptable climatically to most areas in the southeast and midwestern United States. However, as Fig. 1 indicates, potential regions of sugarcane production are limited to relatively small areas of the continental United States.

The identification of potential sugarcane production areas is based on temperature, potential water availability, and proximity to existing sugarcane production regions. The designated areas in Texas and Florida generally will have more than 300 days of frost-free temperatures annually. The frost-free period in the designated Louisiana area is approximately 240 or more days. The area potentially capable of growing sugarcane in Texas might be enlarged considerably if irrigation water could be provided. However, a conservative assessment includes only the region in the Rio Grande Valley and along the Gulf Coast border of Texas. Even though land may be available for sugarcane production, if water cannot be provided or is too costly, sugarcane production will not be feasible.

The estimated total area in the entire region of potential sugarcane production is approximately 20 million hectares (1 hectare = approximately 2.5 acres) (Table 1). Roughly one-half of this area is classified as land in farms. Out of this 10 million hectares, approximately 3.2 million hectares is cropland that is either harvested or used for pasture, slightly less than 1 million hectares is woodland, and

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*Research performed under Contract No. W-7405-ENG 92. The detailed results of this study are to be published in late 1978 or early 1979 by the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151.

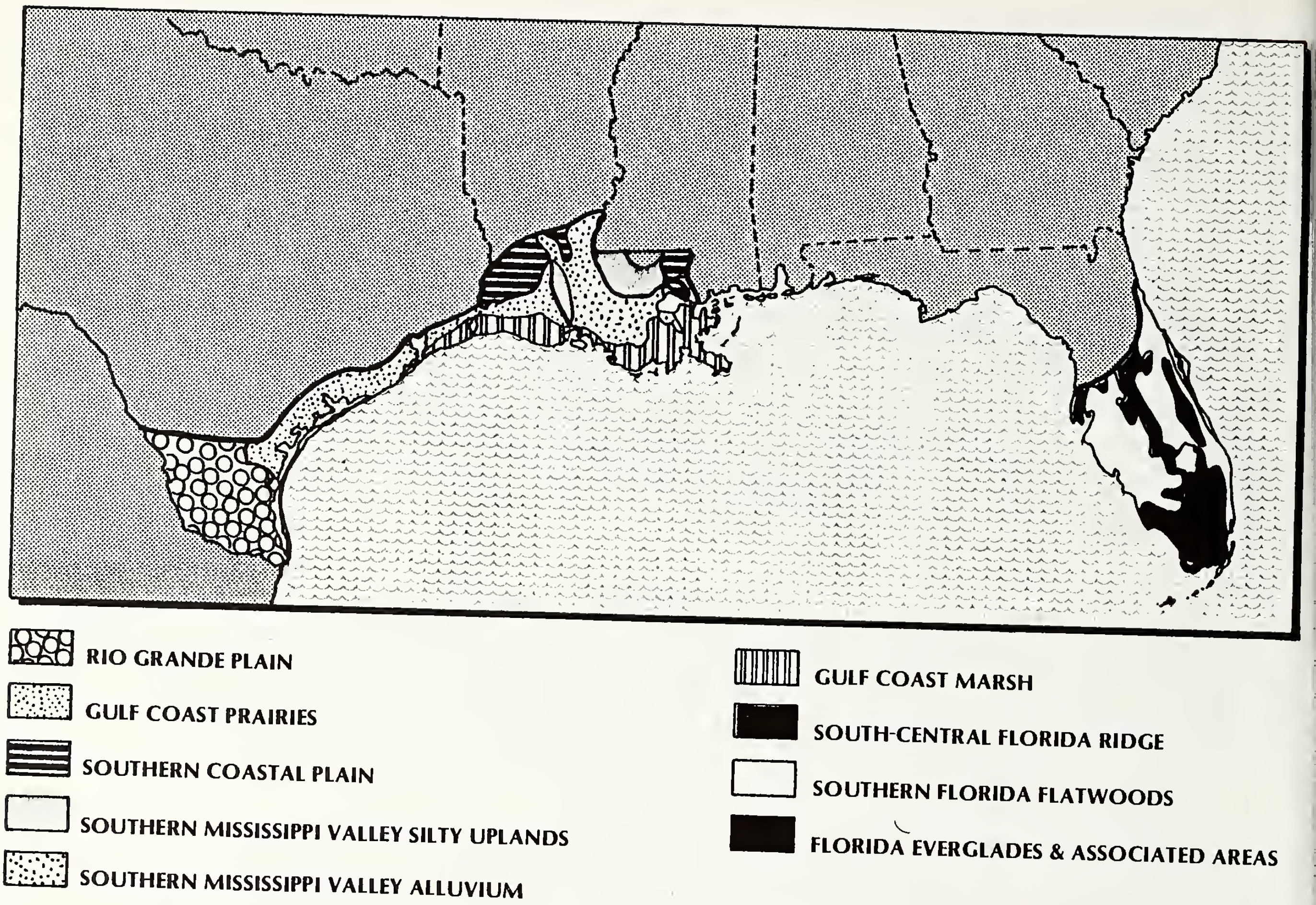
RIO GRANDE PLAIN
GULF COAST PRAIRIES
SOUTHERN COASTAL PLAIN
SOUTHERN MISSISSIPPI VALLEY SILTY UPLANDS
SOUTHERN MISSISSIPPI VALLEY ALLUVIUM
GULF COAST MARSH
SOUTH-CENTRAL FLORIDA RIDGE
SOUTHERN FLORIDA FLATWOODS
FLORIDA EVERGLADES & ASSOCIATED AREAS

Figure 1. Major Land Resource Areas Within Potential Regions of Sugarcane Production

approximately 5.9 million hectares is "other land in farms". Within the category "cropland harvested or used for pasture", approximately 800,000 hectares is pasture land. Cropland used for pasture plus woodland equals approximately 1.8 million hectares, which compares to approximately 250,000 hectares of sugarcane currently being produced in these three states. If, for example, the current area devoted to sugarcane production were to be doubled, it would take approximately 6% of the total cropland and woodland area of 4.2 million hectares.

Table 1. Land use in potential sugarcane production regions, 1974
(1,000 hectares)

	Cropland harvested or pasture	Woodland	Other land in farms
Southeast Texas	1,325	145	3,050
Louisiana	1,160	330	760
Florida	755	500	2,045
TOTAL	3,240	975	5,855

An important consideration in considering the potential future production of sugarcane is the large areas in Florida and Louisiana that are classified as natural wetlands. Wetlands include swamps, marshes, bogs, and other places where the land surface is usually covered to some degree by water. These lands generally are productive fish and wildlife habitats, and there is concern in some circles that the wetlands are being destroyed without regard to environmental and natural resource considerations. Needless to say, there is controversy over the extent of protection necessary for these lands. The ultimate resolution of the degree of protection extended to wetland regions could be an important factor affecting the development of large areas for sugarcane production in Florida and Louisiana, if such production were economically feasible.

CROPLAND DEVELOPMENT COSTS

Practically all land not currently used for agricultural production will require basically three types of operations to prepare for the first sugarcane crop. These include land clearing and leveling (where necessary), installation of drainage systems, and installation of an irrigation system where rainfall is not sufficient to sustain optimum sugarcane growth.

Land-clearing costs vary according to location and depend upon the type of soil (clay or sand), kind and size of tree cover, general characteristics of the terrain (flat or hilly), amount of drainage required, and to a lesser extent, labor costs.

Based on published reports and primary information collected from land development contractors and soil drainage specialists in each area, cropland development costs were estimated. These costs vary over a wide range, from a low of $480 per hectare in some parts of Florida, up to over $1,400 per hectare in heavily wooded areas of Louisiana (Table 2). The inclusion of subsurface drainage could increase total land development costs by several hundred dollars per hectare over these estimates.

Table 2. Summary of approximate total costs of cropland development for sugarcane in Florida, Texas, and Louisiana, 1978

Region	Dollars per hectare
Florida	480 - 670
Louisiana	1,000 - 1,300
Texas (furrow irrigated)	1,000 - 1,165[a]

Source: Estimated by T. A. McClure, based on information from various sources.

(a) Does not include installation of subsurface drainage pipe, which would increase costs by approximately $600 per hectare, assuming 6-inch plastic tubing was utilized.

Table 3 shows the above investment costs for land development on an annualized basis, assuming a payoff period of 30 years at an interest rate of 9%. The annualized development costs are estimated to range from $45-$65 per hectare on Florida sandy soils and from $95 to approximately $125 per hectare in Louisiana and the Texas Rio Grande Valley. Naturally, the cost on an annual basis would vary according to the designated payoff period and interest rate. For example, if the payoff period were reduced from 30 years to 15 years, the annualized costs would increase by approximately 26%.

Table 3. Annualized land development costs[a]

	$/hectare	Percent of total sugarcane production costs
Florida sandy soils	45-65	2-3
Louisiana	95-125	6-7
Texas Rio Grande Valley	95-115	5-6

Source: Calculated by author.

(a) Amortized over 30 years at 9 percent interest rate.

The cost of land development as a percentage of total sugarcane production costs is approximately 2-3% in Florida, and 5-7% in Texas and Louisiana. Overall, if land acquisition charges are included charges are included with land development costs, the annual land costs for sugarcane production are estimated to comprise approximately 10-13% of the total cost of producing and harvesting sugarcane and delivering it to a mill.

SUGARCANE PRODUCTION COSTS

Tables 4 and 5 indicate some of the estimated effects of close spacing upon sugarcane and sweet sorghum production costs. Close spacing refers to various means of reducing the amount of space between sugarcane rows. Normally, rows are spaced at 5-foot intervals. Close-spaced rows may be approximately 1-3 feet apart. Since there is no close-spaced sugarcane grown commercially, these costs must necessarily be regarded as ballpark estimates. Florida costs (Table 4) for conventional production are based upon a detailed survey completed by Dr. D. L. Brooke of the University of Florida for the 1975/76 season. These costs were updated to 1978/79 levels based on price changes for various inputs. These costs were then adjusted to estimate the impact of close spacing, such as the need for higher fertilization, heavier equipment for harvesting, higher transportation costs due to higher yields, etc. It is recognized that equipment is not commercially available to actually harvest close-spaced sugarcane. This adds another degree of uncertainty to these estimates. The Florida situation is complicated further by the fact that conventional cane harvesting uses considerable hand labor, which is considered to be replaced by mechanical harvesters if close spacing for biomass production was to occur. Such replacement presumably could reduce total harvesting costs per hectare, even at higher productivity levels. This assumption, however, needs to be verified under actual operating conditions.

Table 4. Estimated 1978/79 conventional and close-spaced sugarcane costs, Florida muck soils ($/hectare)

	Conventional spacing	Close Spacing	% Change
Preharvest cash expenses	632	671	+6
Harvesting cash expenses	662	561	-11
Ownership + overhead costs	371	449	+21
Cane transportation	139	196	+41
Land charge	330	330	-
Total costs	2,134	2,207	+3
Yield, metric tons/hectare	78	110	+41
Costs per metric ton	$27.36	$20.06	-27

Source: Author's estimates, based on published material by D. L. Brooke, University of Florida, and interviews with sugarcane specialists.

Table 5. Estimated 1978/79 conventional and close-spaced sugarcane costs, Louisiana ($/hectare)

	Conventional spacing	Close Spacing	% Change
Preharvest cash expenses	236	396	+68
Harvesting + transportation	157	305	+94
General overhead	532	785	+48
Land charge	210	210	-
Total costs	1,135	1,696	+49
Yield, metric tons/hectare	54	112	+107
Costs per metric ton	$21.02	$15.14	-28

Source: Author's estimates, based on published material by J. Campbell, Louisiana State University, and interviews with sugarcane specialists

The costs of close-spaced sugarcane on the Florida muck soils is estimated at slightly over $20 per metric ton, compared to slightly over $27 per metric ton under conventional practices. This is based on obtaining the experimental yield of 110 metric tons per hectare. It is recognized that commercial yields may run from 65-85% of experimental yields, which would make the costs per metric ton of close spacing approximately equal to the costs of conventionally spaced sugarcane. In fact, experimental yields of close-spaced cane in Florida exhibited only about 10% increase over experimental yields obtained with standard spacing.

The starting point for sugarcane production costs in Louisiana (Table 5) was data that are developed annually by Dr. Joe Campbell of Louisiana State University. As with Florida, these costs were adjusted for close spacing in accordance with anticipated changes in input requirements and costs. Total costs per hectare for close spacing increased by approximately 50% to about $1,700. However, the sharply increased experimental yields obtained with close spacing, compared to current average commercial yields, result in a decrease in costs per metric ton from approximately $21 down to $15.

COST OF FERMENTABLE SUGARS FROM SUGARCANE

The raw material for producing ethanol from sugar crops is fermentable sugars, which includes sucrose plus invert sugars. The estimated net cost of fermentable sugars in millable cane delivered to a mill before juice extraction is estimated to range from approximately 5.4¢-6.9¢ per lb. in Florida in 1980 dollars, compared to 4.0¢-5.5¢ per lb. in Louisiana (Table 6). In constant dollars, these costs should decline over the next two decades as yields per hectare increase and close-spacing technology is perfected.

Table 6. Estimated costs of fermentable sugars from close-spaced sugarcane[a]
(¢/lb)

	Florida muck soils	Louisiana
1980	5.4 - 6.9	4.0 - 5.5
2000	4.3 - 5.2	3.1 - 4.3

Source: Author's estimates, based on sugarcane production costs and assumed by-product credits for fiber and fuel.

[a] Net cost of fermentable sugars in millable cane delivered to a mill, before juice extraction.

The relative magnitude of these costs is indicated by the fact that if fermentable sugars cost approximately 4.4¢ per lb., the selling price for ethanol (including an allowance for profit) would be approximately $1.20 per gallon, which is the approximate current market price.

It is important to note that the net costs reflected here include a credit for the value of fibrous by-products and the fuel value of combustible organic material contained in sugarcane. These values represent credits against total production costs. Assuming that the Tilby process* is successfully utilized, approximately 50% of the combustible organic material in the millable cane would be marketable at an average assumed value of $40 per metric ton. The remainder of the combustible organic material is assumed to have a fuel value of $20 per metric ton on a dry weight basis. Overall, these credits reduce the cost of fermentable sugars from sugarcane by approximately 10%.

SWEET SORGHUM PRODUCTION COSTS

Sweet sorghum costs (Table 7) were estimated based upon personal interviews with existing commercial producers in the Midwest and with agronomists and agricultural engineers who have grown sweet sorghum under experimental conditions in Louisiana, Mississippi, and Texas. Other important sources of information were crop product budgets developed by the U. S. Department of Agriculture and individual state experiment stations for analogous crops such as grain sorghum, corn, and sugarcane. However, these costs cannot be well defined at this time, since there is so little statistical information available on this crop. Generally speaking, however, planting and cultivation costs for sweet sorghum should be less than for sugarcane, if comparisons with grain sorghum are valid. Harvesting costs will depend somewhat on the methods employed. Presumably, if only the millable stalks were collected, harvesting machinery could be similar to that currently used for sugarcane. On the other hand, a modified, heavy duty forage harvester might be utilized if total plant biomass were to be collected.

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*See paper by T. Anderson, "Tilby Juice Extraction System" elsewhere in these proceedings.

Table 7. Theoretical costs of close-spaced sweet sorghum.
($/hectare)

	Southern U.S.	Midwest U.S.
Preharvest variable costs	270	170
Harvest variable costs	390	335
Machinery ownership & misc.	185	200
Land	215	270
Total	1,060	975
Yield, metric tons/hectare	68	56
Costs per metric ton	$15.60	$17.40

Source: Author's estimates, based on analogies with comparable crops and interviews with personnel knowledgeable in sweet sorghum production.

Under favorable growing conditions in which high yields are obtained, costs per metric ton of sweet sorghum might range from approximately $15-$18, which would compare favorably with sugarcane costs.

COST OF FERMENTABLE SUGARS FROM SWEET SORGHUM

In 1980 dollars, with an allowance for profit to the grower, fermentable sugars from sweet sorghum might range from approximately 5.0¢-6.0¢ per lb. in the southern United States and from 6.1¢-7.4¢ per lb. in the Midwest (Table 8). Hopefully, future research will indicate whether or not Midwestern costs can be appreciably lowered. These cost estimates are based upon relatively modest sweet sorghum yields currently obtained by a few commercial producers.

Table 8. Theoretical costs of fermentable sugars from close-spaced sweet sorghum[a].
(¢/lb.)

	Southern U.S.	Midwest U.S.
1980	4.9 - 6.0	6.1 - 7.4
2000	3.1 - 3.9	4.2 - 5.0

Source: Author's estimates

[a] Net cost of fermentable sugars in sweet sorghum delivered to a mill, before juice extraction.

COMPARISONS OF SUGARCANE AND SWEET SORGHUM

If one chooses to be optimistic and assumes that experimental yields are not unreasonable, the costs and yields associated with close-spaced sugarcane and sweet sorghum can be noted in Table 9. Here, the net cost of fermentable sugars from sugarcane is approximately 4.0¢-5.0¢ per lb., with a potential ethanol production of 9,000-10,000 liters per hectare (approximately 900-1,000 gallons per acre). In the case of sweet sorghum, ethanol production costs presumably would be lower, but less ethanol would be produced per unit area. This is due to the lower level of fermentable sugars contained in sweet sorghum compared to sugarcane and the assumed lower yields of millable stalks. An important factor to note is that the higher dry matter content of sweet sorghum (32-35%) compared to sugarcane (25-30%) results in greater by-product credits, which reduces the net cost of fermentable sugars.

More likely levels of sugarcane and sweet sorghum yields and costs are indicated in Table 10. Under these assumptions, which basically reflect lower yields, the net costs of fermentable sugars would increase by approximately 1¢ per lb., which would in turn increase the cost of ethanol by approximately 13¢-14¢ per gallon. Ethanol production per hectare would be reduced by approximately 20-25% from levels shown in Table 9.

Table 9. Comparison of sugarcane and sweet sorghum, best case, 1978

	Sugarcane		Sweet sorghum
	Florida	Louisiana	South
Total costs, $/Ha	2,205	1,695	1,060
Millable stalk yield	110 MT	112 MT	68 MT
Total costs/metric ton	$20.05	$15.13	$15.60
Fermentable sugars yield	17.6 MT	16.8 MT	8.8 MT
Total cost fermentable sugars, $/MT	125	101	120
Net cost fermentable sugars, $/MT	108	85	76
Net cost fermentable sugars	4.9¢/1b	3.9¢/1b	3.5¢/1b
Potential ethanol production, liters/hectare	9,790	9,347	4,896

Source: Author's estimates

Table 10. Comparison of sugarcane and sweet sorghum, most likely case, 1978

	Sugarcane		Sweet sorghum
	Florida	Louisiana	South
Total costs, %/Ha	2,090	1,575	975
Millable stalk yield	93 MT	92 MT	52 MT
Total costs/metric ton	$22.45	$17.10	$18.75
Fermentable sugars yield	14 MT	12.9 MT	6.8 MT
Total cost fermentable sugars, $/Ha	149	122	143
Net cost fermentable sugars, $/metric ton	135	110	100
¢/1b	6.1	5.0	4.5
Potential ethanol production, liters/Ha	7,790	7,178	3,784

Source: Author's estimates.

GROWER INCOME COMPARISONS WITH OTHER CROPS

If renewable resources are to be successfully utilized as energy feedstocks, the potential profits to growers must be comparable with alternative land uses. Insofar as sweet sorghum and sugarcane are concerned, alternative land uses depend upon the geographic region being considered. In Louisiana, alternative cropland uses might be for cotton or soybeans, in addition to conventional sugarcane for sugar production. In the Texas Rio Grande Valley, cotton, vegetables, citrus, and conventional sugarcane production would be alternative crops. In the Midwestern United States, corn for grain and soybeans are the major crops currently grown on existing cropland. Other land uses might include pasture, recreation, and urban development in certain areas.

Table 11 indicates potential returns to growers for various crops grown in U. S. mainland sugarcane regions and the Midwestern United States. The data indicate how a hypothetical sweet sorghum and/or sugarcane for biomass production operation would compare to other crops grown in a particular region. The data for conventional crops represent approximate averages based on the period 1975 through 1977. It should be noted that averages may be misleading in that individual growers may achieve much higher or lower yields. Also, prices for commodities may fluctuate as much as 50-100% within a year's time.

The hypothetical estimates for sweet sorghum and close-spaced sugarcane for ethanol production assumed that the new Tilby processing technique will be successfully utilized, and that by-product credits for the fiber and fuel value of these crops would be obtainable. These two data sets are presented to indicate the importance to biomass producers of being compensated for the nonsugar material.

Without the by-product credits, it does not appear that either sweet sorghum or sugarcane could effectively compete with alternative crops in the southern or midwestern United States. On the other hand, sugarcane for ethanol production appears to be more favorable for growers in Louisiana than in Florida, if the 1977 experimental results are indicative. This is due to the much higher yield increases obtained with close spacing in Louisiana than were obtained in Florida. It remains to be verified whether such yield differentials can be maintained year after year under commercial operations.

ENERGY BALANCE

Another aspect of the Battelle studies for the Department of Energy involves estimating the energy balance associated with sugar crops production. The energy input requirements to produce close-spaced sugarcane and sweet sorghum are summarized in Table 12. These estimates include the energy required to manufacture and distribute fertilizers. The importance of fertilizers in calculating an energy balance is exemplified by the large difference in energy inputs required to produce sugarcane on Florida sandy soils, as compared to Florida muck soils. This difference primarily is due to the need for application of nitrogen on sandy soils. Nitrogen manufacture is extremely energy intensive (31,100 btu's per lb. of nitrogen) and the need for high nitrogen applications plus irrigation water will significantly lower energy balances associated with biomass production.

Table 11. Grower income comparisons

Crop	Net income, \$/hectare[a]	
	Including by-product credits	Excluding by-product credits
Sweet sorghum (ethanol)		
Southern U. S.	220	(72)
Midwest U. S.	158	(70)
Close-spaced sugarcane (ethanol)		
Florida	(216)	(465)
Louisiana	224	2
Sugarcane (sugar)[b]		
Florida	45	---
Louisiana	(6)	---
Soybeans[b]		
Louisiana	156	---
Midwest U. S.	313	---
Cotton[b]		
Louisiana	248	---
Texas	305	---
Corn[b]		
Midwest U. S.	257	---

Source: Author's computations, based on various published and unpublished data.

[a] Excluding land charges.

[b] Based on average production costs, prices, and crop yields from 1975-77.

Table 12. Energy input requirements to produce close-spaced sugarcane and sweet sorghum (Megajoules/metric ton dry weight)

	Close-spaced sugarcane	Sweet sorghum
Florida, muck soils	1,150	---
Florida, sandy soils	1,720	---
Louisiana	1,365	---
Southern U.S.	---	845
Midwestern U. S.	---	1,050

Source: Author's estimates.

For comparison purposes, 1,000 megajoules is approximately equal to the energy contained in 8.2 gallons of regular grade gasoline.

The theoretical energy output from 1 metric ton of millable sugarcane is indicated in Fig. 2. The energy equivalent of the ethanol is approximately 1,700 megajoules, while that of the combustible material in the millable cane is slightly less than 2,000 megajoules. Together, the energy value is about 3,700 megajoules, which is equivalent to approximately 30 gallons of gasoline. The energy contained in the field residues would provide an additional 1,200 megajoules, or 10 gallons of gasoline.

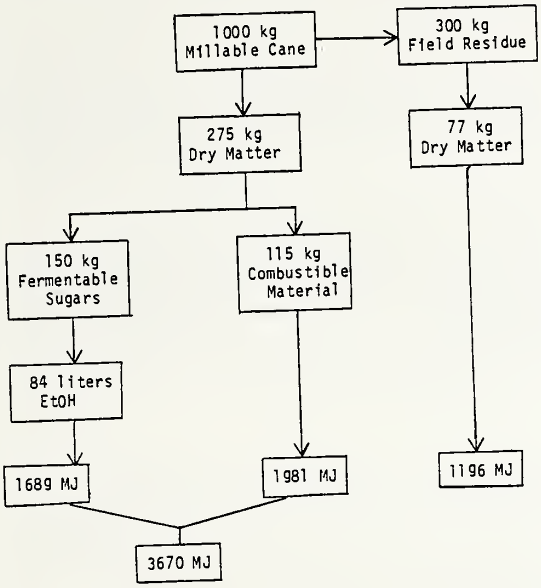

Figure 2. Theoretical energy output from 1.0 metric ton millable sugarcane.

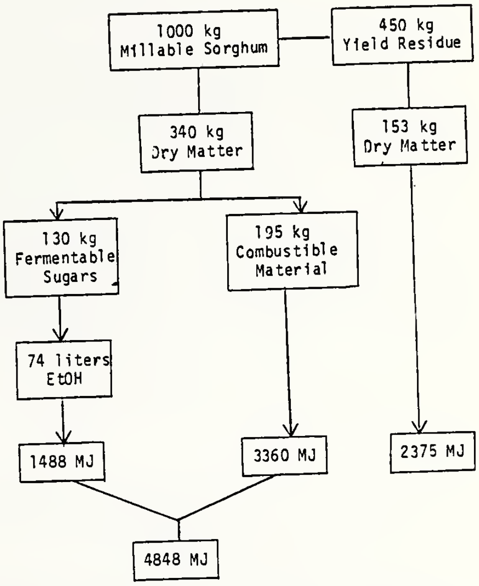

Figure 3. Theoretical energy output from 1.0 metric ton millable sweet sorghum.

The theoretical energy output from 1 metric ton of millable sweet sorghum (Fig. 3) is about 30% higher than from sugarcane. However, this is misleading in that about 70% of this energy is in the form of low grade fuels represented by the combustible material. Since the fermentable sugars content of sweet sorghum is lower than sugarcane, potential ethanol production per metric ton also would be lower by about 10-12%.

ACKNOWLEDGEMENTS

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THE TILBY CANE SEPARATION SYSTEM

T. A. Anderson
Ander-Cane, Inc.
Naples, Florida

ABSTRACT

Recent experience with the Tilby Separator, which separates cane stalks into the outer rind and juice-containing pith, is described.

INTRODUCTION

In 1963 Ted Tilby, a Canadian architect-inventor, determined that the outer fiber of sugar cane could be blended with resin and pressed into especially strong boards at a relatively low cost. To secure this fiber, however, equipment would first have to be developed which could separate cane stalks into two components, the outer fiber, and the inner pith which contained the sugar juice. Accordingly, a Canadian company was formed to carry out this equipment development.

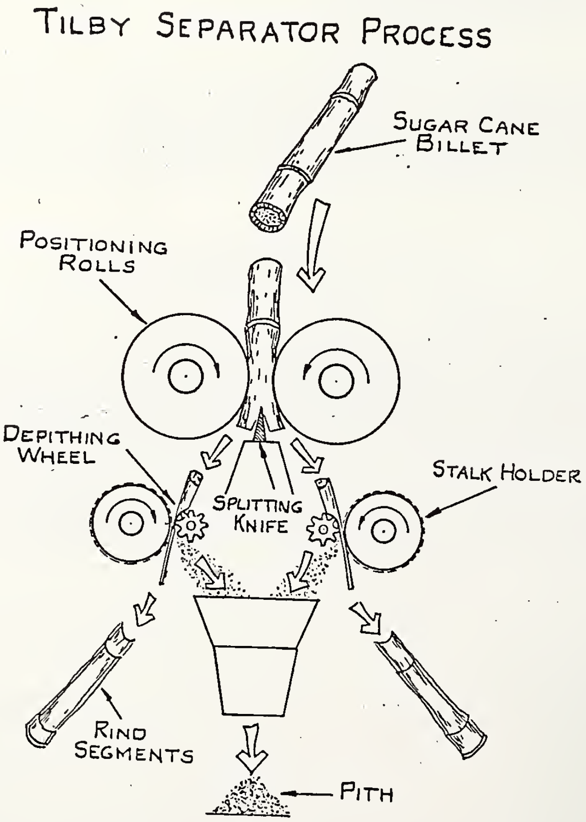
The complexities of separating cane proved to be so extensive as to require some 14 years of engineering design, product testing, and re-design before the reliability and productivity of the equipment became fully satisfactory. Many tests were conducted in the West Indies sugar industry and the first commercial operation got underway in Pahokee, Florida in December, 1977. The Florida program, as its objectives in separating cane, sought to obtain the following products:

a. Clean and contaminant-free pith from which sugar can be easily diffused.
b. Clean, uncrushed fiber with its strength unimpaired
c. Wax-rich epidermis

Furthermore, these products were to be obtained with relatively low:

a. Fixed capital investment
b. Operating and energy costs

The following chart illustrates how the separator equipment processes the billets cut from sugar cane stalks.



PRODUCTION EXPERIENCE TO DATE

The separator equipment was operated in Pahokee, Florida during the first half of 1978, processing up to 15 tons of sugar cane per hour. Some experience has also been gained in processing sweet sorghum and grain sorghum. These operations showed the degree to which the cane should be de-trashed before being separated in order that the equipment operate on an optimal basis. It also showed the preferred length of the cane billets to be processed. Data was obtained on labor costs, power costs, and maintenance expenses so that the overall costs of separating cane can now be more accurately estimated.

This experience with the separator has shown that it is more logical to cut cane, lontitudinally, in half, than to crush it. Cutting is not only cheaper than crushing, but it keeps the various fractions of cane in a much more valuable condition. Crushing mixes all the dirt and contaminants of the cane field in with the sugar juice. Then considerable capital, processing costs, and energy are required to extract the juice from these varied contaminants. In the separator process, the dirt is never mashed into the sugar juice in the first place so no cost is required to then cleanse the dirt out of the juice.

The substantial value of fiber in making boards is due to its unusually high strength. When cane is crushed, however, this natural quality is destroyed. Thus on economic grounds it is essential that cane not be crushed. High strength boards, such as those made from oak trees and cane fiber, sell for over $400 per ton. Thus cane fiber, as a finished product, may be worth more than cane juice as a finished product. This means that those varieties of cane that have as much fiber as juice may have an especially high overall value, assuming the separator system is used in processing the cane. Furthermore, capital and processing costs for making cane-board appear to be less on a per ton basis than for making sugar out of the juice obtained from cane stalks.

FUTURE PLANS

Inasmuch as the production technology for separating cane has been proven to be reliable and economically feasible on a small scale, future plans will focus on evaluating the difficulties which might be encountered if the level of operations were to be greatly increased. Other short-term plans include:

1. Further development of the equipment needed to process the cane-fiber into boards.
2. Use of existing equipment to make 4' x 8' panels, ½" thick, from cane-fiber and fiber from sweet sorghum.
3. Use of screw presses to extract the sugar juice from separated pith.
4. Analysis of production technology and costs of extracting wax from the epidermis of cane.
5. Improvement of system for de-trashing cane.
6. Analysis of what modifications would be required in sugar mills to take full advantage of the Tilby Separator System.
7. Use of cane-fiber in making paper.
8. Use of pith, from which sugar has been pressed, as cattle feed.

The potential role of the Tilby separator system in the nation's energy program is now being evaluated by the U.S. Department of Energy and the Battelle Institute. The cost of energy obtained from sugar crops obviously could be reduced if:

(a) The cost of obtaining the juice from the stalks could be lessened as expected by the use of separator equipment.
(b) More valuable by-products could be obtained from the stalks to help absorb much of the cost of the stalks themselves.

Any such reduction in the cost of energy from sugar crops would of course increase the potential economic viability of these crops as major future sources of energy.

One goal under serious consideration in regard to the amount of energy which might be obtained annually from sugar crops is three quads (3,000 trillion BTU). This volume would require the production of some 600 million tons of sugar crops, from which about 65 million tons of fiber would be obtained. Economic analyses of this sized production requires, among other things, consideration of the ability of the wood products market to absorb this much fiber. If the market for this fiber were to prove to be relatively strong then the fiber price would be higher and it could absorb more of the costs involved in obtaining energy from sugar crops. Such increased cost absorption would then lower the cost of obtaining energy from sugar crops.

To help evaluate the possible strength of demand for large volumes of fiber entering the wood products market, data was gathered on the size and growth rate of this market. Tables I and II show a preliminary estimate how fiber from sugar crops might be absorbed into these markets. In general, a first look suggests these markets are large enough and show enough growth to be able to absorb 65 million tons of fiber annually without generating significant downward pressure on prices.

Table I

Consumption of Wood, Plywood and Paper
(mils. of tons)

	1977	Yearly Average Rate of Growth	2,000	Increase Over 1977
Softwood	75	3%	150	75
Hardwood	20	3%	40	20
Plywood				
Soft	18	2.5%	33	15
Hard	5	3.0%	10	5
Paper	52	5.0%	157	105
Total	170	3.7%	390	220

Table II

Market Penetration by Fiber from Sugar Crops by Year 2000

As replacement for:	Tons (mils.)	SHARE OF	
		Total Market	Market Growth
Softwood	22	15%	29%
Hardwood	8	20%	40%
Plywood			
Soft	3	9%	20%
Hard	1	10%	20%
Paper*	32	20%	30%
Total	66	17%	30%

*Fiber may replace wood pulp in the production of 20% of the total paper supply.

Table II shows that of the long-term increase in the need for paper and wood products, about 40% could be supplied from fiber. Since the output of the U.S. forestry industry is expected to be relatively stable over the decades ahead, the remaining 60% of material required would have to be supplied from foreign nations or from other types of plants. Thus, the planned production of products from fibers does not appear likely to generate an oversupply. Rather, with tree production unlikely to expand significantly, and with demand doubling by the year 2000, the fiber based products can be looked upon as a partial means of easing a shortfall in the domestic supply of forest products.

The price implication of this preliminary supply and demand analysis is that the value of wood products is likely to be at least maintained over the longer term, even if some 65 million tons of fiber are supplied annually from sugar crops. Correspondingly, if the price structure of wood products is maintained, fiber prices, in all probability, should also be stable. In turn, higher fiber prices mean lower costs for the energy obtained from sugar crops because the fiber will be able to absorb proportionately more of the costs of these crops.

SUMMARY

The Tilby separator system provides a major new technology for processing sugar crops. It makes possible more products and higher quality products from crops than can be obtained from present technology. It also provides for a reduction in energy requirements, capital investment, and processing costs per ton of material handled. However, before reasonably precise values can be estimated regarding these varied benefits, more production experience is required. Furthermore, operations have been conducted on only a small scale to-date. Development of equipment to operate on a relatively large scale could present problems as yet unknown. Thus, while the separator system offers the promise of substantial economic gains to the sugar industry, much work remains to be done before this promise can become a reality.

CRITERIA FOR EVALUATING MILLING QUALITY OF POTENTIAL VARIETIES IN LOUISIANA[1]

B. L. Legendre
USDA Sugarcane Field Station
Houma, Louisiana

ABSTRACT

Fiber content and normal juice extraction are two criteria used in evaluating milling quality of potential varieties in Louisiana. Complete mill tests on 88 varieties of the 1970 through 1976 CP series conducted during the 1973 to 1978 milling seasons indicate a significant trend in recent years toward the selection of varieties with higher fiber content and lower normal juice extraction. A decrease in normal juice extraction usually means a decrease in recoverable sugar per ton of cane and a higher fiber content. The data on normal juice extraction obtained from these complete mill tests are used in assigning varietal correction factors (VCF) to each variety. The VCF then allows for the estimation of recoverable sugar per ton of cane from a knowledge of the Brix and sucrose content of sample mill or crusher juice.

INTRODUCTION

Complete mill tests have traditionally begun with the in-field selection stage of the variety testing program at the U.S. Sugarcane Field Laboratory, Houma, Louisiana (3). These tests are designed to measure fiber and normal juice extraction percent cane of each variety to estimate the yield of recoverable sugar per ton of cane (7). These data when compared to those of a standard milled in the same series of tests are used to assign a varietal correction factor (VCF) to each new variety. The VCF is then used in subsequent tests to estimate recoverable sugar per ton of cane from a knowledge of the Brix and sucrose content of sample mill or crusher juice for that variety, and its use corrects for varietal differences in normal juice extraction.

James and Miller (6) report that normal juice extraction and fiber percent cane are highly correlated but the association is negative; this indicates that as fiber content increases, normal juice extraction decreases. Further, fiber content is also negatively associated with sucrose yield; as fiber increases, the yield of recoverable sucrose decreases. Normal juice extraction is positively associated with VCF; as normal juice extraction increases, so does the VCF.

This paper reviews the evaluation of new varieties of the 1970 through 1976 CP series with two or more complete mill tests for fiber and normal juice extraction percent cane and the effect that these two criteria of milling quality have on the VCF assigned to the variety.

MATERIALS AND METHODS

A complete mill test to evaluate milling quality requires a minimum of 36.2 kg of hand-cleaned cane (7). The procedures involved in conducting a complete mill test have been previously described (2,3,7). Normally, duplicate samples are processed on each date of testing and 8 to 10 tests are required before the VCF is considered permanent for a new variety. Usually four tests represent the plant cane crop, four tests the first stubble crop, and two tests the second stubble crop.

For each test, weights and analytical data on primary juices and bagasse (8) supply the necessary information for the calculation of fiber and normal juice extraction percent cane and for the sucrose reduction factor (2,3,7). The constant value of 0.985 is used for the Brix reduction factor. The commercial varieties, CP 52-68 or 65-357, whose milling quality was established in earlier tests, are used as the standards in assigning VCF to promising new varieties.

The two criteria of milling quality, fiber and normal juice extraction percent cane, and the assigned VCF for the 1970 through 1976 series, were individually analyzed by regression analysis with series year as the independent variable and the milling quality criteria as the dependent variable. All possible correlation coefficients were calculated among series year, fiber, normal juice extraction and VCF.

RESULTS AND DISCUSSION

The average fiber content (FC), normal juice extraction (NJE), and VCF for the 88 varieties of the 1970 through 1976 CP series for which complete mill tests were conducted during the 1973 through 1978 harvest seasons at the U.S. Sugarcane Field Laboratory, Houma, Louisiana are shown in Table 1. Though there was considerable variation in FC and NJE from year to year, there was a significant positive correlation between series year and FC and a significant negative correlation between series year and NJE (Table 2). These associations would indicate that FC is increasing and NJE is decreasing with each new series tested by complete mill tests.

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[1] A contribution from USDA, SEA, AR in cooperation with the Louisiana Agricultural Experiment Station, Louisiana State University.

Table 1. Average fiber content, normal juice extraction percent cane (NJE) and varietal correction factor (VCF) of each CP series from 1970 through 1976.

CP Series	No. of Varieties	Fiber Content	NJE	VCF
		(%)	(%)	
1970	10	11.7	81.7	1.01
1971	11	13.3	79.3	0.99
1972	10	12.4	81.3	1.03
1973	9	12.8	79.4	1.01
1974	14	13.0	79.6	1.02
1975	17	11.9	80.9	1.04
1976	17	13.9	78.4	1.04
Mean	88	12.7	80.1	1.02

Table 2. Correlation coefficients between year of CP series, fiber content, normal juice extraction percent cane (NJE) and varietal correction factor (VCF).

	Year	Fiber Content	NJE	VCF
		(%)	(%)	
Year	--	.21*	-.28**	.40**
Fiber content (%)	.21*	--	-.93**	-.62**
NJE (%)	-.28**	-.93**	--	.69**
VCF	.40**	-.62**	.69**	--

*, ** Significant at the 5 and 1% levels of probability, respectively.

In an effort to improve the yield of cane per hectare, more emphasis has been placed on plant population in the initial stages of selection. However, there exists a positive association between stalk population and FC (5) which might explain the recent trend toward increased FC and decreased NJE. Without selection against high fiber clones in the initial stages of selection, there might be a tendency toward increased frequency of clones with an unacceptable level of fiber if selection for stalk population were successful.

In the present study there was a significant positive correlation between series year and VCF, indicating that the assigned VCF increased in magnitude. According to Arceneaux (1,2,3) an increase in FC and a decrease in NJE normally means a lower VCF. A probable explanation for the rise in assigned VCF was the apparent change in the FC and NJE of the standard variety, CP 65-357, used exclusively in complete mill tests since the 1977 milling season (Table 3). Davidson (4) stated that any reliable standard should have a constant FC and NJE, making allowances for slight yearly variations. However, it is impossible to predict when and if the reaction of the standard variety will deviate beyond acceptable limits. Adjusting the NJE of CP 65-357 to pre-1975 levels for the 1978 milling season, the average VCF as assigned to the 1976 CP series would decrease from 1.04 to 1.01. Accordingly, the significant positive correlation between series year and VCF would disappear.

Table 3. Fiber content and normal juice extraction percent cane (NJE) for the standard variety, CP 65-357.

Year of Test	Fiber Content	NJE
	(%)	(%)
Pre-1975	11.9	81.6
1975	11.9	81.0
1976	12.1	80.2
1977	12.6	80.8
1978	13.5	78.6

The interrelationships among FC, NJE, and VCF for all 88 varieties of the 1970 through 1976 CP series are shown in Table 2. As FC increased, the VCF decreased (r = -.63**); as NJE decreased, the VCF also decreased (r = +.69**). Further, the negative association between FC and NJE meant that as FC increased, NJE decreased. All of the above relationships have been previously reported (4,6).

In summary, the VCF alone can not be used as the exclusive indicator of milling quality of a candidate variety due to the potential abnormal behavior of the standard variety. As an alternative, the VCF might be used as a tool in calculating the potential yield of recoverable sugar per ton of cane with the more tangible characters of FC and NJE as the criteria for evaluating milling quality. According to James and Miller (6), selecting on the basis of percent primary juice extraction is as reliable as estimating milling quality from percent fiber. This would allow for the discarding of clones with poor milling quality during early stages of selection in the breeding program. Then the VCF as assigned from subsequent mill tests could be used to estimate recoverable sugar per ton of cane for those varieties advanced beyond the in-field selection stage. With further study, the need for a standard variety might be dropped and in its place some fixed FC and NJE could be used in assigning a VCF to a new variety after complete milling tests give the FC and NJE of the candidate variety.

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SUCROSE DESTRUCTION: INVERSION LOSS DETERMINED BY HIGH PRESSURE LIQUID CHROMATOGRAPHY[1]

By Margaret A. Clarke and Mary Ann Brannan
Cane Sugar Refining Research Project, Inc.
1100 Robert E. Lee Blvd.
New Orleans, Louisiana 70179

ABSTRACT

Sucrose decomposition to invert sugars is responsible for losses in processing, particularly at acid pH. An HPLC (High Pressure Liquid Chromatography) method, which determines glucose and fructose individually, is used to observe sucrose destruction under processing conditions of temperature and pH. Results, as applied to sucrose loss in cane and raw sugar and refined sugar production, are discussed.

INTRODUCTION

The loss of sugar in processing is a problem of major concern to manufacturers of raw and refined sugar. The chemical destruction of sucrose accounts for most of the unknown loss, so-called, although from an economic viewpoint, this loss is only too well-known. Chemical destruction includes thermal degradation, the reactions of sucrose that proceed more rapidly at high temperatures.

Many different pathways of destruction of sucrose are possible; they have been studied with a general division into reactions under acid conditions (7,11,15) and reactions under basic conditions (1,8,11,12). The present study investigates sucrose destruction under acid conditions. The initial reaction is the inversion of sucrose, catalyzed by acid and heat, to form glucose and fructose, the mixture known as invert sugar. This reaction proceeds even at neutral and basic pH, though to a much smaller degree (13). Inversion is also caused by invertase enzyme but that pathway will not be considered here.

Inversion can occur in cane, as soon as it is cut or damaged, in stored cane, in juice and syrup in mills, in raw sugar stored at too high a temperature, in refined sugar that is improperly stored - anywhere there are conditions of acidity, heat and moisture.

The fructose and glucose that are formed initially can react further to make organic acids and non-sugar compounds, often dark-coloured ones. Thus there is a double problem from inversion: not only is there a loss of sucrose, but also there is the subsequent formation of non-sugars and color, which must be removed in processing, and which cause further sucrose loss by taking sucrose with them into molasses. This second loss, from the melassigenic effect of non-sugars, is often greater than the original loss by inversion. There is also additional processing required to remove these compounds from the product.

In previous work on inversion, the reaction has usually been studied by following the concentration of the glucose-fructose mixture by a copper reducing titration, such as the Lane-Eynon titration procedure (5). The problem with this analysis is that it determines all reducing substances in solution and not just glucose and fructose. An additional problem is that any difference in glucose and fructose concentrations that might arise from subsequent degradation reactions cannot be observed.

The alternative method has been to follow the loss in concentration of sucrose, usually by optical rotation techniques, or to observe the amount of acid consumed. These analyses, like the reducing sugars titration, have the fault that they measure a property or reaction that is the sum of several components, rather than measure the individual components. The problem has always been that there was no convenient specific analysis for glucose and fructose.

HIGH PRESSURE LIQUID CHROMATOGRAPHY

A new instrumental technique, high pressure liquid chromatography (HPLC), is extremely well suited to investigation of sucrose inversion. Sugars are separated by HPLC so that sucrose, glucose and fructose (and any other sugars present) may be analyzed individually. A water solution of sugars, in appropriate concentrations, may be injected directly into the instrument; there is no derivatization or other pretreatment required.

HPLC separates compounds on a small column, at room temperature. Good resolution is achieved by use of packing with a very small particle size. In order to get sufficient flow, high pressure drops are required - approximately 500 to 2000 psi in sugar analysis. Compounds are separated on the basis of their polarity and molecular weights. It is similar to liquid partition chromatography, but a much greater range of compounds can be separated in reasonable time because of the high prssure and small-sized packing material. Analysis is both quantitative and qualitative.

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[1] This work was performed in cooperation with the Southern Regional Research Center of SEA, USDA.

Sugars, mono-, di- and trisaccharides, are separated very efficiently on commercially prepared columns of microparticles (porous particles with chemically bonded coating, about 10 µm in diameter) in a solvent mixture of acetonitrile and water, and detected by refractive index monitor (3,4,8,10, 14,16,19). Other organic compounds are not retained by these carbohydrate analysis columns. The main problem heretofore with HPLC of sugars has been the accuracy of determinations at the lower limits of detection (4).

Separate peaks appear for glucose, fructose and sucrose, and for any other sugars present. HPLC is the only available technique to analyze separately for glucose and fructose directly and at the same time. It avoids the problem in reducing sugars titrations by clearly showing the relative quantities of fructose and glucose present. There is no interference of one sugar with another. A typical chromatogram is shown in Fig. 1. It is possible to see if fructose and/or glucose have further decomposed.

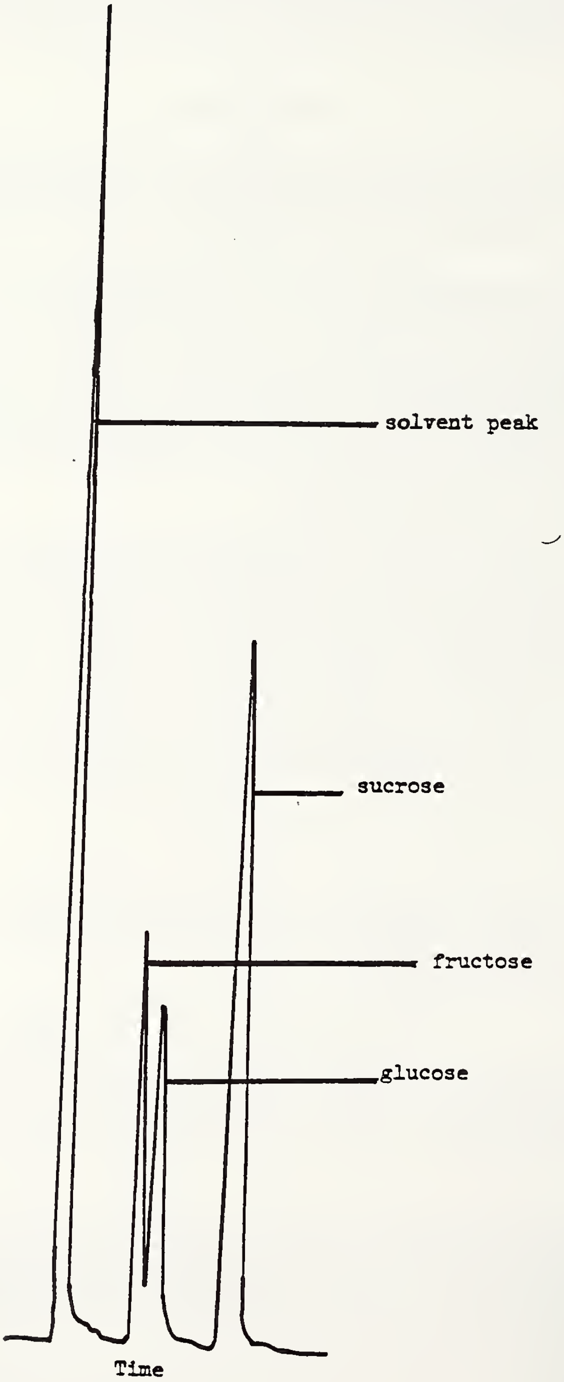

Fig. 1. Chromatogram of fructose, glucose and sucrose.

It must be emphasized that, although the HPLC technique is reliable, rapid, and straightforward, it demands considerable care in sample preparation and column maintainance for satisfactory operation. As this new technique is further developed, no doubt hardier columns will be produced, and experimental technique can become less meticulous, but this is not the state of affairs at the present time.

REACTION CONDITIONS

Most of this study was carried out in 60 brix solutions, in simulated refinery liquors. Some experiments were run in 15 brix solutions, to compare with cane juice.

Previous work has generally been done in dilute solution (7,11), e.g. 10% sucrose, where the inversion reaction is reported to proceed more rapidly at short times than we have observed at either 15 or 60 brix. Differences may be due to methods of measurement, i.e. indirect measurement of the sugars compared to the more direct measurement by HPLC, or to differences in reaction conditions. We have found that the reaction rate increases with increased sucrose concentration but not in direct proportion to the concentration. Because a water molecule is added to a sucrose molecule in the reaction, at higher brix where there is not an unlimited supply of free water molecules available, the reaction is slowed down (17). In other words, reaction of sucrose with a water molecule becomes a rate-determining step at high brix.

The concentration of salts, or ionic strength, of the solution is another important factor in the reaction. The ionic strength affects the activity, or true effective concentration, of the reactants, and hence the rate of their reaction. The relatively high concentration of salts in cane juice (both in and out of the cane plant) should have a positive effect on the reaction rate. The high concentration of organic acids and their salts has a considerable buffering effect, so that if a low pH develops, it will be maintained in the juice. As sucrose and glucose are decomposed, more organic acids form, and further decrease the pH. These factors make the problem of inversion, and sucrose loss, in cane and cane juice even more severe.

The salt concentrations in this work are controlled by potassium chloride concentration: a 60 brix solution prepared with 0.1M KCl approximates a 60 brix solution of a 0.5 - 1.0% ash raw sugar. Cane juice with 3 - 5% ash on solids also compares to a 15 brix solution prepared with 0.1M KCl.

The reaction rate also increases with increased temperature and decreased pH. It is apparent that conditions in cane juice of low pH (high acidity) are ideal for rapid inversion.

METHODS AND MATERIALS

Sample Preparation

Reagents: Sucrose: a high-grade unblended first strike white sugar was used for all samples. This sucrose was recrystallized from methanol-water, and the purity and recovery of the recrystallized sample were the same as those of the unrecrystallized on HPLC; so, the unrecrystallized sucrose was used.

Glucose and fructose: Eastman or Baker reagent grade D-glucose and D-fructose were used. Samples recrystallized from ethanol-water gave purities and recoveries on HPLC similar to those of unrecrystallized samples; so, the latter were used.

Water: all water, including that used as HPLC solvent which received further treatment, was deionized.

Sample solutions, 60 brix in sucrose or 30 brix in both glucose and fructose, were prepared with water or with a 0.1M or 0.2M solution of KCl, (Baker Reagent grade). The pH of samples was adjusted with dilute HCl or NaOH; samples were stirred magnetically for five minutes before a reading was taken. A Corning Model 12 pH meter was used with Corning Combination pH electrode. Readings were made at room temperature (25 C). Measurements were made to compare pH readings at room temperature and reaction temperature. The pH was read again after reaction time was complete, after cooling and before dilution.

Twelve grams of each solution were weighed into 25-ml Erlenmeyer flasks fitted with ground glass stoppers. The flasks, weighted down with lead rings on the exterior, were placed in a wire basket and submerged up to stopper level in an oil bath (Magni-Whirl Constant Temperature Bath, constant to ±0.5 C). One 12 g sample was prepared for each time interval required, so that there would be no interim removal of sample with concomitant losses by evaporation.

When the reaction time was complete, the sample flask was removed from the constant temperature bath and cooled in an ice bath. The sample was then analytically transferred to a 50 ml volumetric flask, and diluted to volume with water. When sucrose was present in more than five times the concentration of glucose and fructose, a 10 ml/aliquot of this solution was further diluted to 50 ml for sucrose analysis. Fructose and glucose samples, i.e. those initially containing only fructose and glucose, were diluted to 500 ml. Samples were then analyzed by HPLC.

If it was necessary to store a sample, the sample was frozen. Attempts were made to preserve samples by the addition of formaldehyde, but formaldehyde interfered with the column function.

High Pressure Liquid Chromatography

All analyses were carried out using a Waters Associates (Waters Associates, Milford, Mass. 01757) Model No. ALC/GPC 244, with Model 6000A pump, U6K injector, R-401 differential refractive index detector, and µBondapak-carbohydrate column (30 cm x 4 mm i.d.), connected to a Honeywell Electronik 194 recorder. Flow rates were generally 1.5 ml/min varying from 1.0 to 2.0 ml/min. Injection volume was generally 10 µl for sucrose, and 25 µl for fructose-glucose samples, depending on sample concentration, delivered by Pressure-Lok syringes (Precision Sampling Corp., Baton Rouge, La. 70895). Because there was often a great difference between sucrose and glucose-fructose concentrations, it was frequently necessary to make two injections on different dilutions of the 60 brix sample. All samples, including those for test procedures for instrumental response, were run in duplicate.

Sample Cleanup: A pre-column of about 1" depth in a micropipette of Corasil/AX Bondapak, strong anion exchanger packing material (Waters Assoc.), was used. The resin was washed several times with sample solution before a sample was collected for injection. Each pre-column was used for three sample solutions. The sample was filtered through a Swinney adaptor on a syringe, fitted with a 5.0 µm Millipore fluorocarbon filter, before going on to the pre-column.

Solvents: Organic solvents used were Burdick and Jackson Distilled in Glass (Burdick and Jackson Labs., Muskegon, Michigan 49442). Deionized water was passed over a column of strong base anion exchange resin in the OH^- form, then over a column of strong acid, cationic resin in the H^+ form, and then over a column of activated granular carbon, to ensure removal of salts and organics. A solvent mixture of 83 ml acetonitrile to 17 ml water was used for all analyses. The solvents were mixed, filtered through a 5.0 µm pore size Millipore fluoro-carbon filter, and sonicated for five minutes. (Disontegrator Model, Ultrasonic Industries Inc., Plainview, N.Y.) During operation of the chromatograph, the Model 440 UV detector was kept running to monitor the solvent for impurity.

Column Care: The µBondapak-carbohydrate column loses separating and resolving ability with time in use. To ensure as long a lifetime as possible, the column was washed with a 50% methanol-water mixture after each day's operation, and was stored in this solvent mixture.

Calibration: Peak height and peak area (by triangulation) measurements were compared, and peak height was found to be the more accurate and reproducible measurement. Three methods of calibration were investigated:

1. Calibration curves for sucrose, glucose and fructose, in the pertinent concentration ranges of 5 mg/ml to 100 mg/ml were prepared. Slopes differed from one sugar to another because of the different refractive indices of the sugars. The response of the column and detector (peak height versus concentration) was examined for linearity and for changes in slope with time. The effect of total amounts of sugars in a sample upon the column response to each sugar was investigated, as was the effect of sample volume and concentration of sample upon response. Frequency and extent of recalibration were checked.

2. The use of internal standards was investigated, using methyl-a-D-glucopyranoside. Changes in peak height, and ratio of the internal standard to sugar with varying amounts of each sugar and of total sugars were investigated.

3. Bracketing of samples with standards of higher and lower concentrations was investigated. An approximation of the concentrations of the sugars in a sample was obtained by comparing peak heights with a calibration curve; standard solutions of concentrations just above and below sample concentrations were selected and injected, and the unknown concentration read from a graph of peak height versus concentration of the two standards. The accuracy and precision of this method were investigated over a range of absolute and relative concentrations of sugars, and over changes in the response of a column with time. Concentration of sugars in the treated sample was determined as percent of the original 7.2 g sample of sucrose.

RESULTS AND DISCUSSION

Optimization of the Analytical Method

pH determination: The pH was measured at room temperature (25) and at reaction temperatures, in buffered solutions, both aqueous and 60 brix in sucrose, to determine if it was necessary to measure pH at reaction temperature or if a room temperature measurement would suffice. Results are shown in Table 1.

Table 1. pH at room and reaction temperature

pH \ Temp. °C (F°)	25 (77)	80 (176)	90 (194)
Aqueous, pH4	4.00	3.90	3.90
Aqueous, pH 7	7.00	6.90	6.90
60 bx, pH4	4.00	4.05	4.00
60 bx, pH7	6.40	6.50	6.55

It was concluded that, for the 60 brix samples, pH measurement could be made at room temperature.

Chromatographic Procedures: It was determined that peak height was a more accurate method of quantifying the sample than was peak area by triangulation. However, it may be that peak area determination by automatic integration is more accurate than the peak height calculation. There was not an integrator available for this study.

Tests were conducted to check the response of the column and the detector to changes in the concentrations of sugars at a constant volume of sample injection. Peak height did not change in the desired linear fashion, as shown by the results in Table 2. This disparity must be taken into account in the choice of a method for calibration.

Table 2. Response (peak height) variation with sample concentration. All injections: 10 µl; attenuation X8.

Sample conc.	Fructose	Glucose	Sucrose
5 mg/ml	20	18	14
10 mg/ml	44	36	26.5
20 mg/ml	98	64	57

Another series of tests examined the effect of different dilutions on a constant sample size. There was a considerable effect, as shown in Table 3, indicating that the instrument responds to the concentration of the sugar injected rather than only to the total amount. Ideally, of course, when concentration is halved, peak height should also be halved. It would be preferable to have a response to either amount or concentration, rather than to both.

Table 3. Response (peak height) variation with sample dilution. All injections: 0.2 mg; attenuation X8.

Sample vol.	Fructose	Glucose	Sucrose
10 µl	137	102	57
20 µl	93	86	50
40 µl	78	66	40

There is a solvent front (18) where the sample comes into contact with the column, and it is at this point, because of the partition factor in the separating function of the column, that the sample dilution has its effect. It has been suggested (18) that using a sample solvent identical to the eluting solvent would decrease this problem, but in this study such a change was not possible because the sugars were not sufficiently soluble in 83% acetonitrile.

The possibility that the instrument response to one sugar might be affected by the concentrations of the other sugars present was investigated. Results, as shown in Table 4, show that there is essentially no such interdependency.

Table 4. Response (peak height) variation of sugars injected singly and in combination. All injections: 20 mg/ml; attentuation X8.

Sample vol.	Fructose alone	Fructose:glucose:sucrose,1:1:1
5 µl	54.8	55.2
10 µl	111.5	112.0

Table 5. Variation in response (peak height) with varying ratios of sugars.

Sample vol.	Sugars (mg)			Peak height		
	fruct.	gluc.	sucr.	fruct.	gluc.	sucr.
5 µl	0.05	0.05	0.05	27.0	22.5	17
	0.05	0.05	0.10	26.5	22.0	34
10 µl	0.10	0.10	0.10	54.5	43.5	34
	0.10	0.10	0.20	53.0	42.5	68
20 µl	0.20	0.20	0.20	99.0	80.0	81.0
	0.20	0.20	0.40	97.0	79.0	122.0

The pre-column treatment was tested to see if any sugars were lost from the sample when it was passed over the Corasil. Results on HPLC showed that no sugars were absorbed by the Corasil treatment. This pre-column treatment removed color from samples; it took out anions, both organic and inorganic, that could react with the column packing material causing errors in the results and shortening the life of the column. Careful filtration of all material going over the column was necessary to remove both particulate matter that might block the column, and microorganisms that might grow there.

Column Deterioration: It is known that the packing material of the µBondapak-carbohydrate column contains an amino group, although the manufacturers do not reveal the specific nature of the material.

Use of several such columns in this laboratory, and information from workers in other laboratories, indicate that the column has a finite lifetime (at C.S.R.R.P., up to six months of steady use, with full precautions, or about 2000 runs) no matter how carefully washing and sample clean-up procedures are followed. It is postulated here that the amine groups on the packing material enter into a Maillard-type reaction with the sugars in the samples. In this way, the active sites on the column are gradually used up. Reaction products form on the column and may remain there, changing the response and increasing back pressure. The column can be operated at pH2 to pH8, but the manufacturer recommends that pH7 to 8 be used. Presumably this is because some Maillard-type reactions proceed at a faster rate at lower pH. The manufacturer also recommends daily washing and storage in 50% methanol-water - a procedure that greatly extends column efficiency and life. Apparently the wash removes the reaction products, and extends the useful life of the column, although it is inevitable that the column will be exhausted within a certain time, depending on the usage load.

Calibration: Calibration curves for glucose, fructose and sucrose were not linear for peak height versus concentration (see Fig. 2,3, and 4). The slope of the curves changed with column lifetime, as expected, but because of the non-linearity, a one- or two-point frequent recalibration was not possible. This type of calibration procedure was, therefore, not suitable for the purpose of the current extensive study. This method could be used if only a few samples were to be analyzed within one or two days, or if a lower degree of accuracy were permissible. The different response of the instrument to different sample concentrations is related to the variation shown in Table 2, and to the solvent front effect.

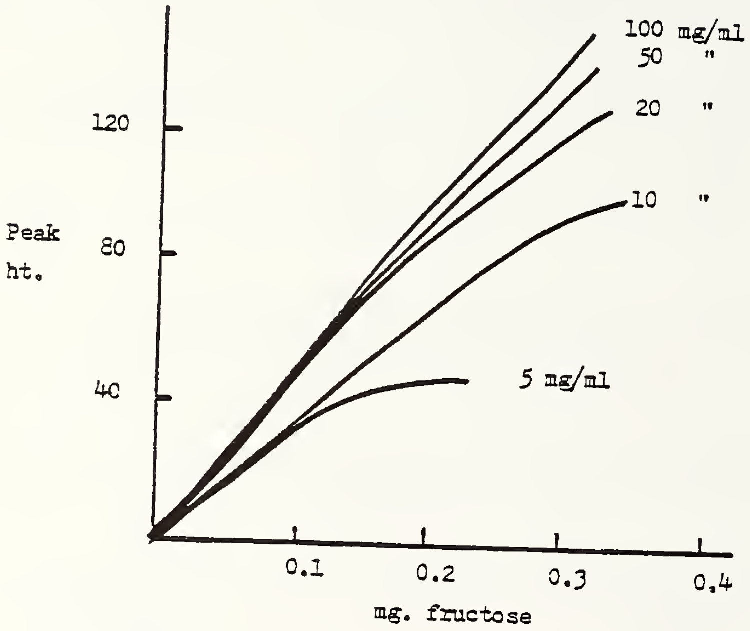

Fig. 2. Calibration curves for fructose.

Then the use of methyl-a-(d)-glucopyranoside as an internal standard was investigated, it was found that the internal standard and the sugars did not respond proportionately on the column, as shown in Table 6. The K-value, $\frac{\text{pk. ht.sugar}}{\text{pk.ht.standard}} \times \frac{\text{wt. standard}}{\text{wt. sugar}}$, for each sugar varied with the relative amounts of sugar to standard. This technique was, therefore, also unsuitable for the current study.

Bracketing of samples with standard solutions of higher and lower concentrations appeared to give the best results. This technique is quite time-consuming, because to analyze a sample for sucrose, glucose and fructose, the sample must first be run and approximations of the three concentrations read from calibration curves of each of the three sugars. Then two standards for each sugar must be prepared, and these six standards run. This gives a total of seven runs for each sample, or 14 counting

Table 6. Variation in K-value with variation in ratio of sugar to standard. Injection volume: 10 µl.

Sugar: standard	K - values		
	fruc.	gluc.	sucr.
1:1 (10 mg/ml each)	0.85	0.80	0.66
2:1 (20 mg/ml sugar to 10 mg/ml std.)	0.72	0.68	0.56
2.5:1 (25 mg/ml sugar to mg/ml std.)	0.65	0.62	0.52

the necessary duplicate runs, at different dilutions, on any one sample (one run for sucrose, the other for fructose and glucose), there were usually even more runs necessary. Combining several samples to be run as a series with their standards is sometimes possible, and can cut down on the number of runs.

This technique, although lengthy, eliminates response factors caused by changes in the column. It minimizes the effect of relative concentrations of the sugars in the samples, and of the sample size ratio. The precision of this method, using the quantities described herein, may be expressed as follows in Table 7.

Table 7. Precision of measurements by method of bracketing.

Sugar	Coefficent of variation
Fructose	0.9% to 1.5%
Glucose	0.7% to 1.5%
Sucrose	0.8% to 1.4%

The lowest limit of detection was 2.5 μg of sugar in 100 μl of sample or 25 ppm. Best accuracy and precision were obtained when dilution and attenuation were such that peak heights were 10% to 50% or full scale.

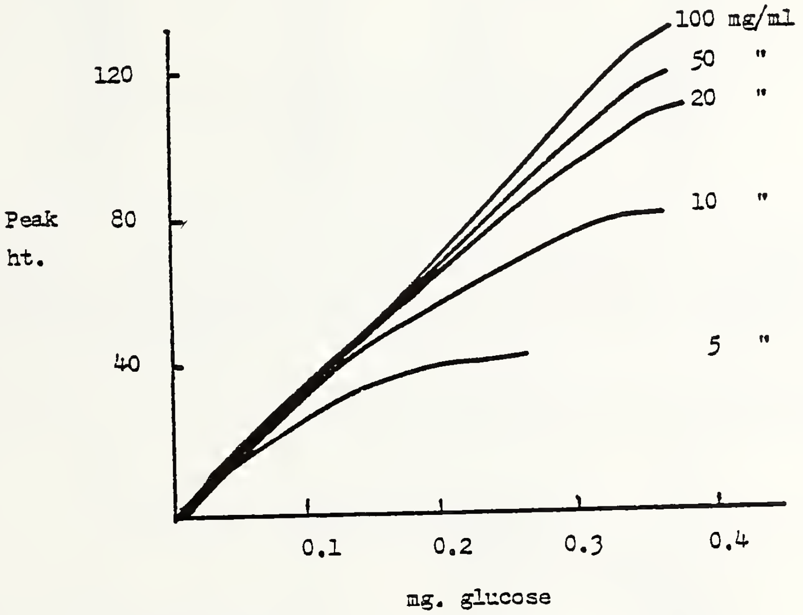

Fig. 3. Calibration curves for glucose.

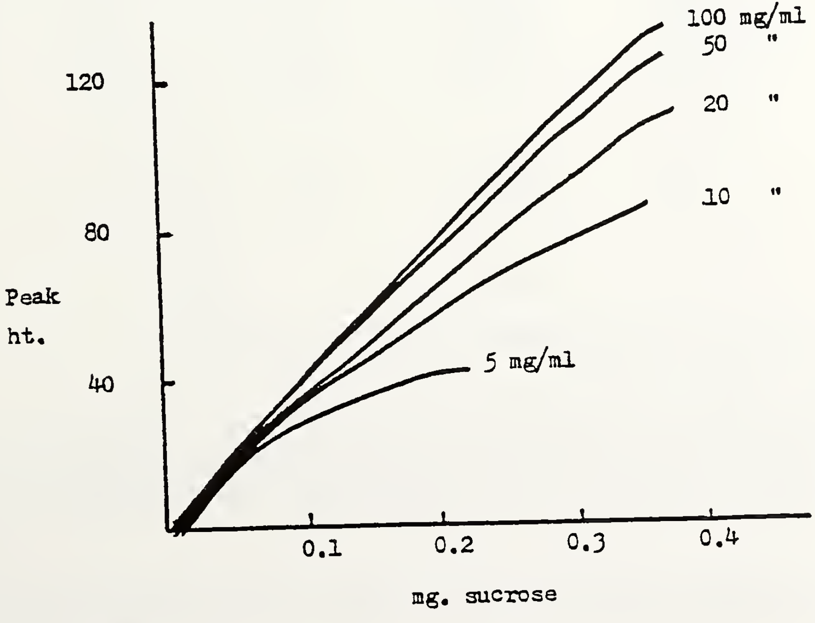

Fig. 4. Calibration curves for sucrose.

Comparison with Standard Methods: Comparison of results obtained on a series of molasses samples show that (in Table 8) the sum of glucose and fructose by HPLC is lower than the reducing sugars figure obtained by a Munson and Walker copper reduction method. This is to be expected, since the copper method determines all reducing substances in the sample, not all of which are invert sugar.

The sucrose values by HPLC are also considerably lower than the values found by Clerget. Again, this is to be expected, because the Clerget simply gives a sum of all compounds polarizing light in a certain manner. It must be pointed out that the HPLC analyses were done from a few days to several weeks after the standard tests, and that, although the samples were kept under refrigeration, some decomposition could have occurred. If this were so, however, the HPLC reducing sugars value might have been expected to be higher.

Table 8. Comparison of sugar in molasses by HPLC with reducing sugars by Munson and Walker, and sucrose by Clerget.

% Reducing sugars Munson and Walker	% fructose + % glucose	Δ	% sucrose, Clerget	% sucrose HPLC	Δ
20.40	18.50	-1.9	33.32	28.50	-4.82
17.86	14.75	-3.11	33.32	28.25	-5.07
16.61	14.75	-1.86	37.26	32.25	-5.01
15.57	14.25	-1.32	39.38	33.75	-5.63
20.41	17.50	-2.91	33.47	31.25	-2.22
24.77	22.00	-2.77	34.68	32.00	-2.68
22.53	19.50	-3.03	35.29	33.50	-1.79
16.36	14.00	-2.36	33.78	31.00	-2.78
17.79	14.50	-3.29	38.17	35.25	-3.92

Decomposition of Sucrose: The decomposition of sucrose in water at 60 brix concentration, at pH 3 to 6, at 80 C, is represented in Fig. 5. Table 9 shows the relative amounts of sucrose, glucose and fructose present at different times of reaction. Results are presented as millimole percent of the original sucrose. The change in pH over the reaction time is recorded in Table 14. As expected, the reaction proceeds more rapidly at lower pH; it is well established (2,15,16) that the association of a proton with the sucrose molecule is rate-determining in the kinetics of the reaction. The drop in pH, shown in Table 14, drives the reaction forward in an autocatalytic effect, because of the decrease in pH with increase in reaction time. The pH drops as the reaction proceeds because fructose and sucrose are slightly more acidic than sucrose, and because of the organic acids formed from fructose and glucose decomposition.

Table 9. Decomposition of 60 brix sucrose in water; 80 C (176 F). Concentrations are in millimole percent of the theoretical amount of original sucrose.

Time (h)	Fru	pH3 Glu	Suc	Fru	pH4 Glu	Suc
0.25	1.71	1.71	98.95	0.0	0.0	100.0
0.5	4.45	4.61	95.86	–	–	97.77
1.0	11.89	12.13	86.83	–	–	94.44
1.5	17.59	17.93	82.98	1.09	1.05	95.44
2.0	21.26	21.40	75.51	1.19	1.05	94.82
3.0	36.28	36.28	64.24	2.09	2.14	94.82
4.0	46.84	47.50	50.69	3.19	3.09	92.72
5.0	48.79	50.78	48.07	3.71	3.66	93.77
6.0	56.73	58.92	38.90	4.37	4.23	90.97
24.0	92.39	96.34	2.04	40.89	40.89	53.07
		pH5			pH6	
4.0	.34	.34	96.53	0.0	0.0	96.90
6.0	.48	.48	101.43	–	–	101.05
24,0	7.70	7.94	90.30	3.76	3.73	97.24
		pH7				
4.0	0.0	0.0	101.05			
6.0	–	–	–			
24.0	2.81	2.51	101.75			

Fig. 6 and Table 10 show similar data for aqueous solutions of sucrose at pH 5 to 7, at 90 C (194 F). Experiments run in 0.1M potassium chloride solution (ionic strength = 0.1 M/1, approximating a raw liquor) are shown in Fig. 7 and 8, and Tables 11 and 12.

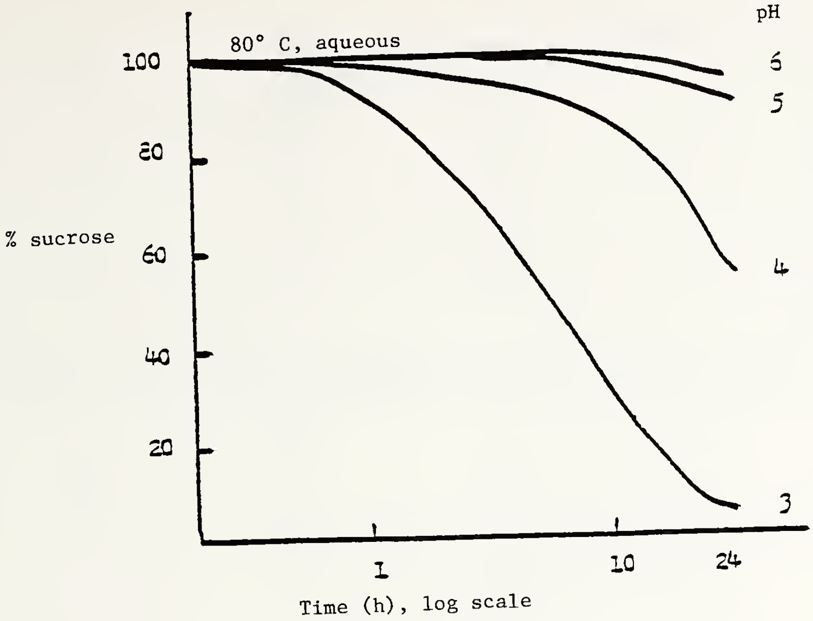

Fig. 5. Decomposition of sucrose at 80 C, in water.

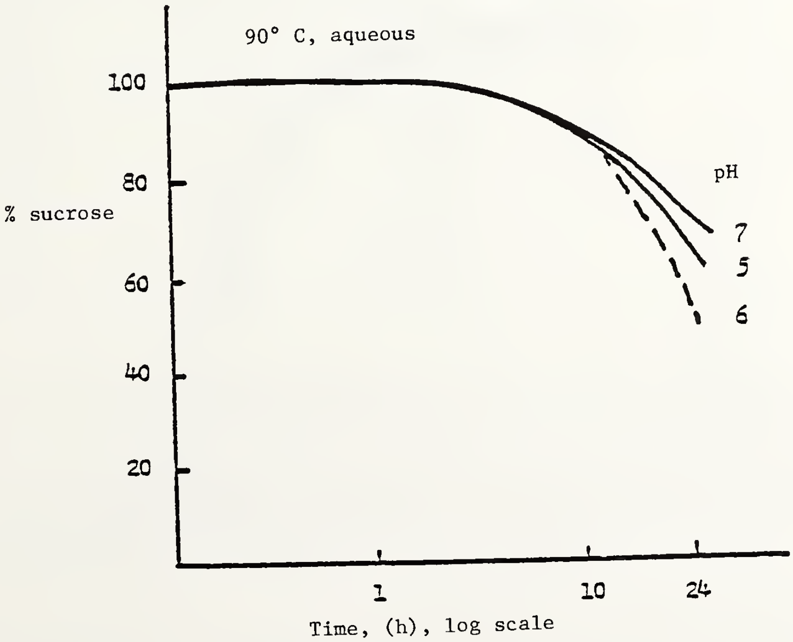

Fig. 6. Decomposition of sucrose at 90 C, in water.

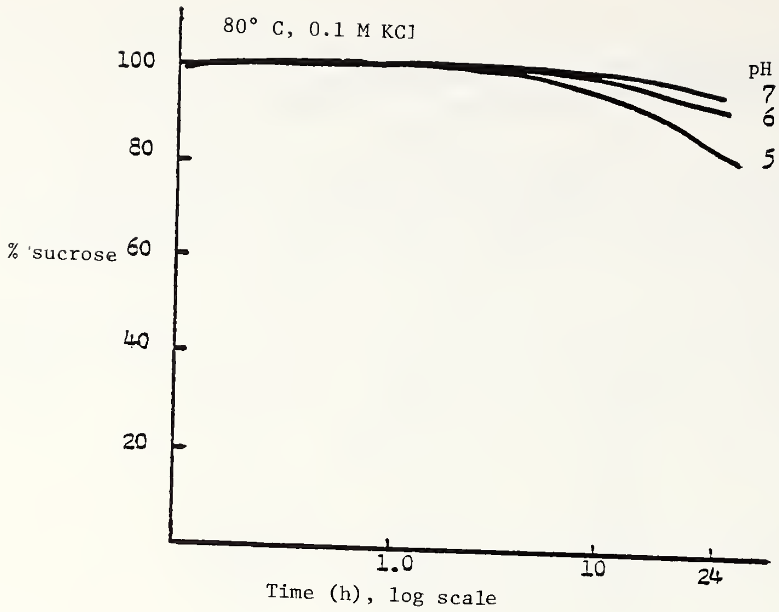

Fig. 7. Decomposition of sucrose at 80 C in 0.1 M KCl.

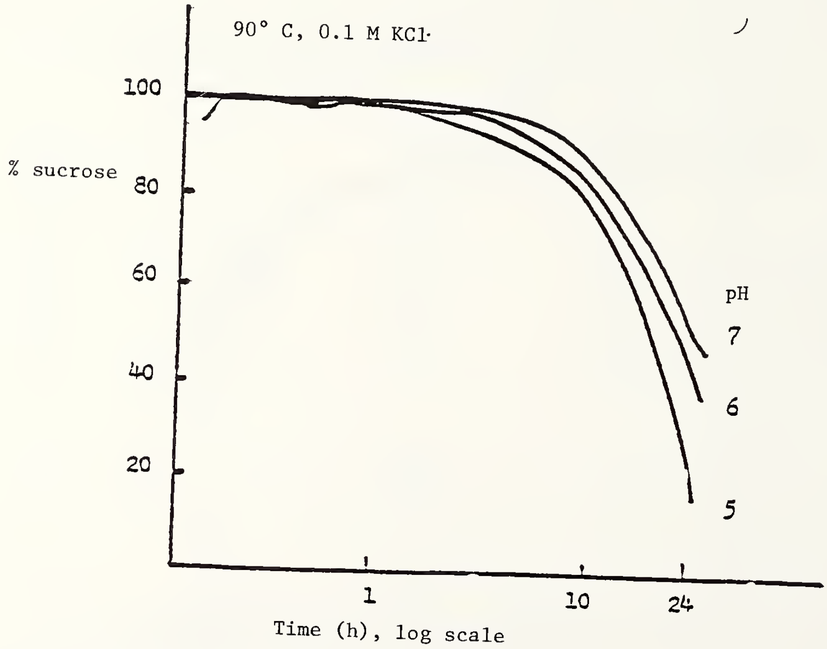

Fig. 8. Decomposition of sucrose at 90 C in 0.1 M KCl.

Table 10. Decomposition of 60 brix sucrose in water; 90 C (194 F). Concentrations are in millimole percent of the theoretical amount of original sucrose.

Time		pH5			pH6	
(h)	Fru	Glu	Suc	Fru	Glu	Suc
2.0	0.0	0.0	100.00	–	–	–
4.0	1.85	1.76	101.05	.29	.29	101.18
6.0	3.04	2.95	98.62	1.05	1.14	96.20
24.0	33.67	35.95	62.53	45.84	48.64	49.31
		pH7				
4.0	.10	.19	102.81			
6.0	.62	.71	98.62			
24.0	30.34	32.33	65.81			

Table 11. Decomposition of 60 brix sucrose in 0.1M KCl solution; 80 C (176 F). Concentrations are in millimole percent of the theoretical amount of original sucrose.

Time		pH5			pH6	
(h)	Fru	Glu	Suc	Fru	Glu	Suc
0.25	0.0	0.0	103.33	–	–	–
0.50	–	–	103.47	–	–	–
1.0	–	–	99.48	–	–	–
1.5	–	–	102.09	–	–	–
2.0	–	–	98.29	0.0	0.0	101.90
3.0	.29	.29	101.38	–	–	–
4.0	.38	.38	101.24	0.0	0.0	100.71
5.0	.48	.48	99.33	–	–	–
6.0	.52	.57	96.20	0.0	0.05	101.24
24.0	11.46	11.89	87.49	3.71	3.71	102.81

Table 12. Decomposition of 60 brix sucrose in 0.1M KCl solution; 90 C (194 F). Concentrations are in millimole percent of the theoretical amount of original sucrose.

Time		pH5			pH6	
(h)	Fru	Glu	Suc	Fru	Glu	Suc
2.0	.57	.67	101.57	0.0	0.0	95.48
3.0	–	–	–	0.0	0.0	100.35
4.0	1.71	1.71	99.33	0.0	0.0	102.43
6.0	2.76	2.71	97.57	1.19	1.33	98.29
24.0	74.18	79.17	14.88	52.45	59.72	38.09
		pH7				
4.0	.10	.19	98.62			
6.0	.52	.57	95.15			
24.0	46.84	50.50	48.26			

Fig. 9 compares the decomposition at pH5 in water and in 0.1M KCl at 80 C (176 F) and 90 C (194 F): it is apparent that the reaction proceeds more rapidly in the solution of higher ionic strength. These data, and the data at 90 C, confirm that ionic strength and increased temperature do affect the reaction rate, as expected at these high concentrations of sucrose, where there is so little free water. At 60 brix sucrose, there are 1.75 moles sucrose to 22.2 moles water. When the 5 moles water that hydrate each sucrose molecule are accounted for, the solution is 13.5M in free water. The reaction of a sucrose molecule with a proton is considered the rate-determining step in sucrose hydrolysis, or inversion, but in these concentrated solutions, the addition of the water molecule is undoubtedly a second rate-determining step (17).

Fig. 10 shows the decomposition of sucrose in water and in 0.2 M KCl, at 15 brix concentration, at pH5 and 80 C (176 F), over 24 h. The data from these runs is shown in Table 13. The data at 0.2 M KCl exceeds the average ash content in cane juice. It can be seen that, after 24 hours in water at pH 5 at 80 C, 4.85% of sucrose is lost. This percent would be much reduced if the pH were raised to neutral as can be seen from Fig. 5 and Table 9, in 60 brix solution, where at pH5, 9.70% sucrose was lost in 24 h, whereas at pH7, only 2.51% invert was found with no measured sucrose loss.

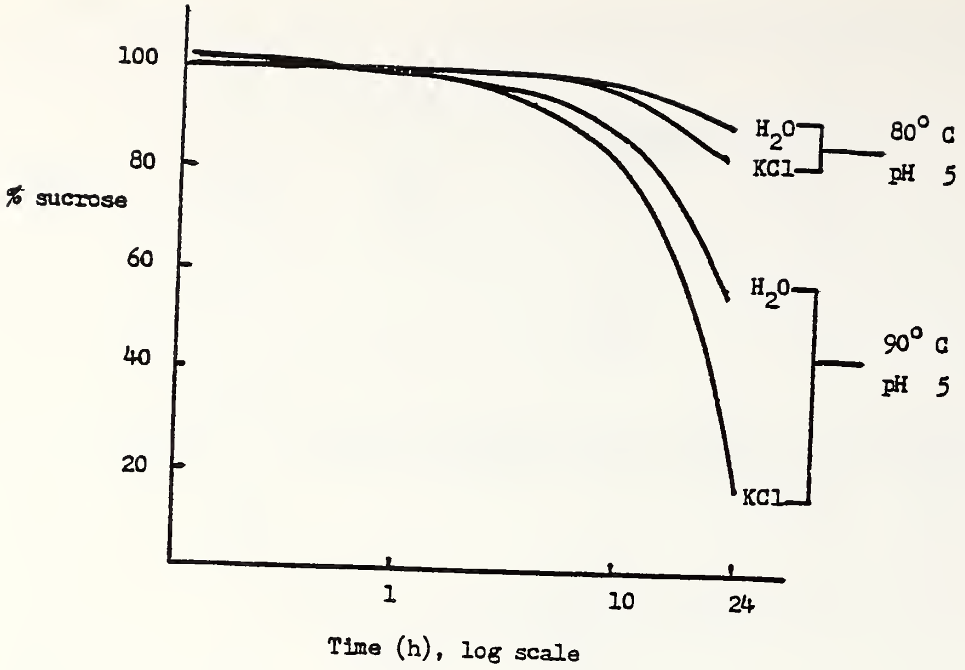

Fig. 9. Comparison of sucrose decomposition in water and 0.1 M KCl.

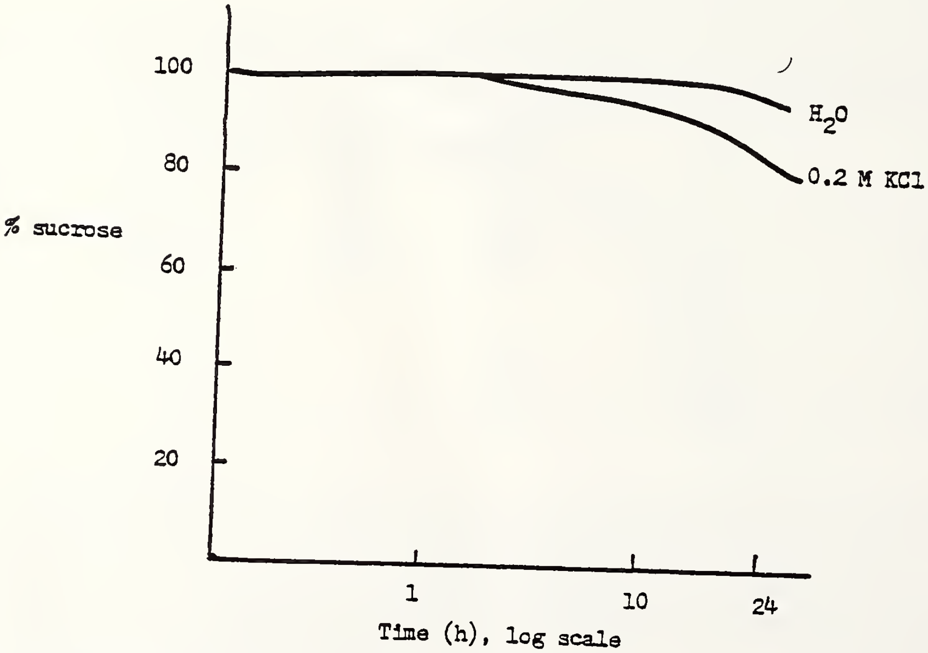

Fig. 10. Decomposition of sucrose, pH 5, 80 C, 15 brix.

Fig. 11 compares decomposition at 60 brix and at 15 brix, at pH5 and 80 C, in water to show the difference in rate with difference in sucrose concentrations. The inversion proceeds somewhat more quickly in the higher brix solution but not in direct proportion to the concentration. Although the reaction is known in the literature (7,11,15) to be dependent directly on sucrose concentration, this dependence is dominant in very dilute solutions (below 10% sucrose), where the protonation of sucrose is the rate-determining step. It is postulated here that this dependence is replaced in concentrated solutions by a joint dependence on sucrose and water concentrations. In these concentrated solutions, water is at a finite concentration, and the addition of a water molecule to the protonated sucrose is postulated to be a second rate-determining step.

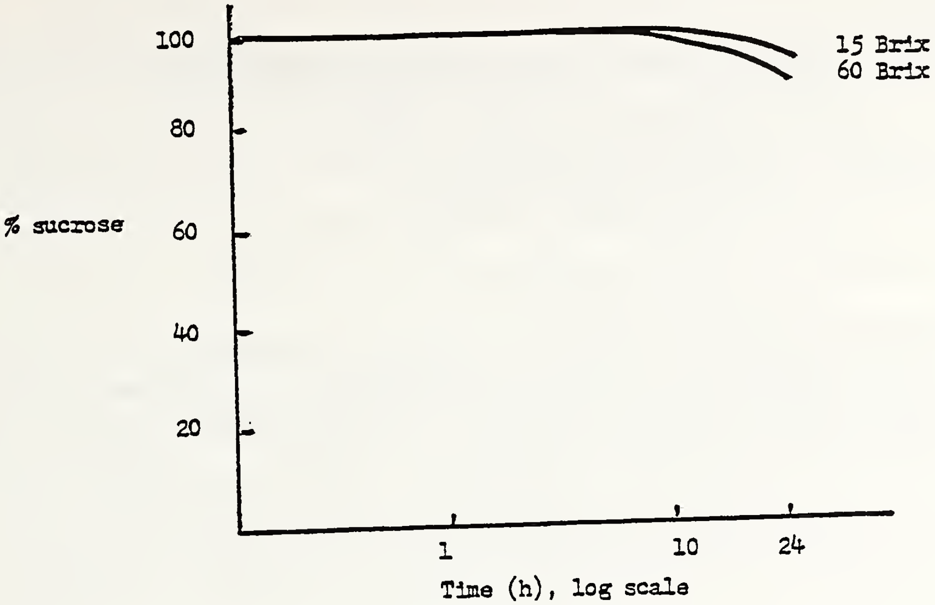

Fig. 11. Decomposition of sucrose, pH 5, 80 C in water.

Table 13. Decomposition of 15 brix sucrose in water and in 0.2M KCl; 80 C (176 F). Concentrations are in millimole percent of the original sucrose.

Time	aqueous			0.2M KCl		
(h)	suc	fru	glu	suc	fru	glu
2.0	100.0	-	-	98.67	-	-
4.0	100.0	-	-	95.83	-	-
6.0	99.24	-	-	96.21	<2.0	<2.0
24.0	95.15	1.24	1.05	80.66	8.06	8.25

Table 14. pH change over 24 h reaction time, read at room temperature in 60 brix and 15 brix solution.

	15 brix 80 C (176 F)	60 brix 80 C (176 F)					60 brix 90 C (194 F)		
Initial pH	5.0	7.05	6.10	5.20	4.05	2.95	7.05	6.10	5.2
pH after 24 h	5.0	4.80	4.60	4.35	3.75	2.70	3.80	3.60	3.40

Table 14 shows the change in pH over the reaction time. The pH drop in the 60 brix solutions increases the reaction rate to some extent, in an autocatalytic manner.

This pH drop taken with data from Tables 9 to 13, show that as the reaction proceeds, the monosaccharides react further and degrade into non-sugars, including organic acids. It is evident that fructose reacts more quickly than glucose. Some of the experimental solutions showed so much decomposition that they were colored at the end of the 24 h run. The literature states (7) that fructose and glucose are most stable at pH 3 to 4, and decompose most rapidly at neutral and basic pH.

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DETERIORATION OF SUGARCANE: LEVELS OF DEXTRAN AND TOTAL POLYSACCHARIDES IN PROCESS STREAMS AT TWO LOUISIANA SUGAR FACTORIES

E. E. Coll, E. J. Roberts,[1] and M. A. Clarke[2]
Southern Regional Research Center
Science and Education Administration
U. S. Department of Agriculture
New Orleans, Louisiana

ABSTRACT

In recent years, attention has been focused on the formation of dextran in mechanically damaged, stale, and freeze-damaged sugarcane. Dextran has been blamed for the high viscosities of syrups and molasses and for the formation of needle-shaped crystals that literally ruin the economics of processing. Tests were made on routine samples collected from two Louisiana sugar factories during the 1977 campaign. Although no frozen cane was processed, wet weather persisted throughout the period. Dextran and total polysaccharides were determined on mixed juice, syrup, B-molasses, final molasses, and raw sugar. A modification of the dextran haze assay was used to determine dextran, and total polysaccharides were determined by a dialysis procedure. The preliminary results in this report show the need for additional effort on studying the problems associated with cane deterioration. For cost effective research, the authors recommend the collection of samples only during periods when deteriorated cane is being processed.

INTRODUCTION

Increasing research has been directed toward understanding and correcting problems of cane deterioration, particularly those associated with chopper harvester operations. Rates of deterioration are primarily functions of the degree of mechanical damage (1,2), cut-to-crush delay (1,2), environmental conditions (2,3), degree of burn and delay of harvest after burning (3,4,5), degree of frost or freeze damage (6), and combinations of these factors. In nearly all of the studies on deterioration, dextran content was one of the most important variables considered in evaluating the degree of cane deterioration.

The extreme processing difficulties experienced with freeze-damaged cane during the 1976 Louisiana harvest demonstrated the need for exploratory work on dextran in domestic cane. These difficulties involved deterioration similar to that observed in chopper-harvested cane. Two projects were initiated: (1) To establish the limits of dextran content on fresh juice by cane variety, date of harvest, and field location, and (2) to determine the dextran content of mixed juice, syrup, B-molasses, final molasses, and raw sugar samples that are routinely collected at two raw sugar factories. The latter project is the subject of this report.

Both projects were expanded to include total polysaccharide analyses to study the dextran/total polysaccharide relationship.

ANALYTICAL METHODS

Two methods for analyzing dextran were considered. One was enzyme-dialysis followed by simultaneous enzymic degradation and dialysis of the product. Measurement of the dialysable products in the second step gives a measure of the content of α-1,6 linked polymeric glucose sequences present in the original sugar. This method is more valuable as a reference procedure than for routine analysis. To obtain data for this report, the modified dextran haze assay (8), originally devised by Nicholson and Horsley (9), was used. The modifications were formulated so that the procedure would be suitable for use in sugar mill laboratories. Both the enzyme-dialysis and the haze methods give values lower than the true dextran values (7,8,9).

Briefly, the modified procedure (8) is as follows: A standard curve is prepared with a solution of known concentration of Dextran 110. Aliquots containing 1 to 12 mg of dextran are pipetted into 25 ml volumetric flasks, each containing 0.5 ml of 10% trichloracetic acid (TCA) and 5.0 ml of 50% standard sucrose solution. Distilled water is added to make a total 12.5 ml before adding absolute ethanol to the 25 ml mark, from a burette. Twenty minutes after mixing, the haze is read at 720 nm against water dilutions of duplicate aliquots. A straight line curve, absorbance vs dextran content, is obtained up to 10 mg of dextran, at which point the curve begins to flatten toward the dextran axis. In practice, the standard curve can be used only after the removal or destruction of sample components that affect the formulation of haze. In the case of mixed juice, excess ions are removed with ion-exchange resins before analysis. For process samples following juice heating, gelatinized starch is broken down with an enzyme prior to treatment with the mixed resins.

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[1] Research Chemist and

[2] Administrator, Cane Sugar Refining Research Project, Inc.

In the dextran assay of raw cane juices, 60 ml of juice is shaken for 10 minutes with 20 g of a mixture of equal weights (dry basis) of Amberlite IR-120(H) and IR-45(OH) resins. After separation of the resin by screening, a 50 ml aliquot of the juice is treated with 10 ml of 10% TCA, and the mixture is vacuum-filtered with 2% of a diatomaceous earth filter aid. A 12.5 ml aliquot of the filtrate is transferred into a 25 ml flask, ethanol is added, and the haze is read as described above.

For raw sugars 50 ml of a 40° brix solution of the sample are mixed with 0.05 g Kleistase GM-16 enzyme and the mixture is incubated at 55C for 1 hour, with agitation every 15 minutes. The mixture is then shaken for 30 minutes with 1.0 g of the mixed resin before the resin is screened and rinsed with distilled water. The sample and washings are diluted to 100 ml, 10 ml of TCA are added, the mixture is filtered, and the haze is developed as described above.

For process materials, the procedure is the same as for raw sugar except that 10 g of the mixed resin is used. To avoid suspected metal ion interference in low purity syrups, application of the procedure has been restricted to process materials having a true purity in excess of 80. Results below 20 ppm on brix are recorded as 20 ppm.

A few changes were made in the analytical procedure (8). The calibration curve was prepared at 60-minute haze development time by using the commercial Dextran T2000[3] (2 million mol wt), Lot No. 8122, of AB Pharmacia, Sweden, rather than their Dextran 110 (110,000 mol wt) at haze development. These compensating changes resulted in approximately 5-10% lower dextran values, but this should not detract from the practical value of approximating the higher molecular weight fraction that many believe promotes crystal elongation. Results of crystal elongation studies are not always conclusive (10). Another change was the substitution of the domestically available enzyme Mycolase (R), Lot No. K7h421, Code 4967-0 (GB Fermentation Industries Inc.) for the Kleistase GM-16 enzyme. The enzyme substitution should have no appreciable effect on the results. The third change was in the methods used for the removal of spent resins and in the final filtration of processed samples. Analytical filter aid was added to the digested sample containing enzyme residues and resin, and the mixture was filtered and washed through a 47 mm Millipore fitted with prefilter only. In samples that are extremely difficult to filter, it may be necessary to substitute a coarse fritted-glass filter for the Millipore. The final filtration, after trichloroacetic acid (TCA) treatment to precipitate proteins, was through the Millipore with a .45 μ membrane and prefilter, but without filter aid. Sufficient turbidity-free filtrate can be obtained in this manner for testing.

Although the modified haze method for dextran determinations was not recommended (8) for samples of true purity below 80, no trouble was encountered and the molasses analyses appear valid.

Total polysaccharides were determined by the procedure of E. J. Roberts (et al) (11).

General Factory Information

Samples were obtained from two raw sugar factories near the center of the cane growing area. Weather conditions, soil types, and cane variety populations were similar. Principal differences were in factory configurations and in operating techniques.

Factory A:

(1) Cane storage yard with derrick--two unloading stations
(2) Cold liming of mixed juice
(3) History of moderate sugar recovery
(4) History of above average molasses production
(5) Raw house and refinery combined--raw sugar samples not available

Factory B:

(1) Cane storage with traveling crane--selective unloading and recovery points
(2) Hot liming of mixed juices
(3) History of excellent sugar recovery
(4) History of minimum molasses production
(5) Raw sugar delivered to storage and/or market

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[3] Names of companies or commercial products are given solely for the purpose of providing specific information; their mention does not imply recommendation or endorsement by the U. S. Department of Agriculture over others not mentioned.

FIELD CONDITIONS DURING HARVEST

The harvest started under ideal conditions that deteriorated rapidly after the first few days. Wet conditions persisted generally until about December 10, although freeze damage never occurred in the 1977 crop. Field conditions corresponding to sample dates are shown in Table 1.

Table 1. Relative Field Conditions During Sampling Periods (1977).

Factory	Sample Series Code	Sample Series Date	Field Conditions
A	A-1	10/19	Dry
	A-2	10/25	Wet
	A-3	11/25	Prolonged Wet
	A-4	12/17	Moderately Wet
B	B-1	10/20	Dry
	B-2	10/24	Wet
	B-3	12/06	Prolonged Wet

RESULTS AND DISCUSSION

The flow of material in process should be kept in mind while studying the results. No attempt was made to schedule inhouse samples to be representative of the mixed juice entering the process. During periods of good harvesting weather, variations in cane quality are small; however, wet conditions produce extreme variations in quality. Both factories have excellent cane-washing facilities, but factory A may not have used them to good advantage during two periods.

Factory A data are presented in Tables 2 and 3.

Table 2: Factory A - Dextran in Mill Samples, ppm on Brix

Sample Series Code	A-1	A-2	A-3	A-4
Date of sample	10/19	10/25	11/25	12/17
Mixed juice	80	790	290	430
Syrup	240	2100	2100	780
B-Molasses	960	1190	3650	1480
Final molasses	1070	2330	4610	1780
Mixed juice titre, ml	1.3	1.2	1.0	0.9

Dextran contents (Table 2) of Series A-1, A-3, and A-4 increase progressively from dilute juice to final molasses, as is expected with the removal of sugar solids. One exception to the progressive increase is on B-molasses, Series A-2; this may be the result of variations in cane quality, as mentioned earlier. Relatively large increase between mixed juice and syrup, with no removal of sugar solids, may be explained by either the formation of dextran during clarification because of Leuconostoc infection, or by changes in the dextran molecular structure, e.g. breakdown to lower molecular weight, that enhance haze formation. The large increase between syrup and B-molasses, Series A-1, may be the result of cane quality variation or of dextran molecular structure change that is amplified in samples of relatively low dextran concentration. Mixed juice titres decreased as the season progressed, probably the result of lower organic acid content in mature cane. All mixed juice samples smelled fresh.

Table 3: Factory A - Starch Equivalent of Total Polysaccharides in Mill Samples, ppm on Brix.

Sample Series Code	A-1	A-2	A-3	A-4
Date of sample	10/19	10/25	11/25	12/17
Mixed juice	24200	17700	12200	45700
Syrup	4100	10800	7600	5000
B-molasses	6900	8700	12000	9000
Final molasses	11300	6000	20400	8400

Total polysaccharide data, Table 3, indicate a high degree of variability that is inconsistent with the dextran values in Table 2 (total polysaccharides include dextran, starch, and other polysaccharides from the sugarcane plant and bacterial infections). Large amounts of soil present in mixed juice samples of Series A-2 and A-3 probably trapped appreciable quantities of the polysaccharides and prevented their being detected by analysis. The data indicate that, although lime clarification removes a high percentage of polysaccharides during periods of low soil, the minimum content at the syrup stage is probably about 3000 ppm on brix. Note the extremely high polysaccharides in mixed juice of Series A-4, which were effectively removed in process. Relative viscosities on final molasses were approximated by hand mixing and were found to be increasing in the order of Series A-1, A-4, A-2, and A-3. This is in direct agreement with the dextran analyses, but is independent of total polysaccharides.

Factory B data are listed in Tables 4 and 5.

Table 4: Factory B - Dextran in Mill Samples, ppm on Brix.

Sample Series Code	B-1	B-2	B-3
Date of sample	10/20	10/24	12/06
Mixed juice	20	80	2910
Syrup	70	500	760
B-molasses	460	1210	2330
Final molasses	620	960	1660
Raw sugar	20	500	330
Mixed juice titre, ml	1.0	1.2	1.6

The distribution of dextran in Factory B samples, Table 4, was similar to that of Factory A, with a few exceptions. Levels of dextran in Series B-1 and B-2 were appreciably lower than in comparable Series A-1 and A-2 samples. The relatively high dextran values in Series B-3 are the result of partially deteriorated cane. In this series, mixed juice, B-molasses, and final molasses samples were foamy and smelled slightly sour. Relative viscosity could not be estimated on the final molasses sample because of the lubrication effect of excess gas and of low brix, about 4° below samples in Series B-1 and B-2. Low brix in molasses could be the result of excessive centrifugal wash during difficult operations that would yield sugar lower than normal in dextran.

No explanation is offered for the fact that the final molasses dextran in Series B-2 and B-3 is less than in comparable samples of B-molasses, other than cane variability. Apparently some dextran is removed during clarification (B-3) when the level in mixed juice is abnormally high and other conditions are right. Mixed juice titres of the B series trended upward during the season, contrary to Factory A results, as could be expected with concurrent increased dextran formation, which produces very small quantities of acetic acid.

Table 5: Factory B - Starch Equivalent of Total Polysaccharides in Mill Samples, ppm on Brix

Sample Series Code	B-1	B-2	B-3
Date of sample	10/20	10/24	12/06
Mixed juice	27400	30800	29200
Syrup	3700	5900	7100
B-molasses	9100	12900	14900
Final molasses	11500	14000	17400
Raw sugar	660	2600	1240

Total polysaccharide data on Factory B samples, Table 5, show remarkably uniform trends with respect to both cane quality and factory operation. In every case, the progressive increase between syrup and final molasses is in line with the amount of sugar solids removed. Soil content of mixed juice was low in all B-samples and did not interfere with polysaccharide analysis. Removal of polysaccharides by clarification was impaired because of the decreasing cane quality, as indicated by syrup analyses. Good agreement was obtained throughout the series on relative concentrations of dextran to total polysaccharides. The two exceptions mentioned earlier for dextran, final molasses in Series B-2 and B-3, are not valid for the polysaccharide results.

Sugar Samples from Other Locations

Three sugar samples were selected (Table 6) for comparison of dextran and total polysaccharides with those of Factory B raws.

Table 6: Dextran and Total Polysaccharides on Random Sugar Samples, ppm on Brix.

Sample	Dextran	Polysaccharides
Factory B raws	20-500	660-2600
Texas raw	90	1270
Philippine bulk raw	60	520
Brazil plantation white*	990	1570

*Difficulties encountered during crystallization; some needle grain formed; known to have dextran problem

Texas raw was of dark color, large grain size, and free flowing compared to the three Louisiana raws from Factory B. Philippine raw was of very dark color, small grain size, and was badly caked. The Brazilian plantation white was not exactly a random sample: it was included because of its history of being difficult to crystallize. It was of mixed crystal size and shape, had been washed thoroughly, and in solution was very turbid and "dirty".

It appears that with proper affination, the Philippine raw would be a high grade crystal, low in both dextran and polysaccharides. The particular Texas raw tested is similar to the Louisiana raw obtained under favorable harvesting conditions. The authors will not speculate on the dextran and total polysaccharides content of the Brazilian sugar prior to intensive washing, since their distribution between molasses and crystal phases is beyond the scope of this paper.

SUMMARY AND CONCLUSIONS

Dextran analyses were completed on routine samples from two Louisiana raw sugar factories to explore the relationship between dextran formation and cane deterioration. Samples included mixed juice, syrup, B-molasses, final molasses, and raw sugar that were collected throughout the harvest season, October 19-December 17, 1977. Dextran was determined by a modified alcohol "haze" method not recommended for samples below 80 true purity; however, good relative values were apparently obtained. In addition to dextran, total polysaccharides were determined by a dialysis/colorimetric method to broaden the scope of work on cane deterioration.

Harvesting conditions were unusually wet throughout the season, although the first sample series from each mill was obtained under dry field conditions. No freeze-damaged cane was processed. There were large increases in dextran between the mixed juice and syrup stages. These increases may be the result of dextran formation during clarification or of molecular structure changes that affect alcohol haze development during analysis. A reduction in dextran during clarification was obtained on one series with slightly sour mixed juice that was relatively high in dextran.

The removal of total polysaccharides during clarification was very good except for periods of high soil content on mixed juice. Soil also interfered with determinations of polysaccharide content on mixed juice samples. Polysaccharide content of syrups was closely related to field conditions, and, as expected, increased in concentration as sugar solids were removed in processing. There was a marked difference in sample uniformity between factories - probably the result of cane storage management and washing operations. Total polysaccharide concentration is related primarily to field conditions. A large amount of these components is removed in clarification.

Work is in progress to determine dextran and total polysaccharide content of juices from four Louisiana commercial cane varieties, to establish a base for minimum values expected from fresh cane.

ACKNOWLEDGEMENTS

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THE USE OF DEXTRANASE IN PROCESSING SOUR CANE

J. A. Polack and H. S. Birkett
Audubon Sugar Institute
Louisiana State University
Baton Rouge, Louisiana 70803

ABSTRACT

The adverse effects of dextrans in processing cane juice have been known for years. The dextrans are glucose polymers, usually produced by the action of the organism Leuconostoc mesenteroides on sucrose. In 1969, Tilbury, working in Jamaica, suggested the use of the enzyme, dextranase, to decompose the dextrans into low-molecular weight species. Australian researchers have developed the procedure and made promising full scale mill trials in recent years. Optimum conditions for dextranase application are reviewed in this paper.

At Audubon Sugar Institute, several trials of dextranase were made in the fall and winter 1977-78. In November 1977, cane was soured by aging 19 days after harvesting, and was subsequently tested. Then in late February, cane which had been left in the field and severely freeze-damaged was also processed. In both cases, treatment of a dilute syrup with dextranase permitted crystallization of sugar--which was impossible with untreated stocks.

Further work, including obtaining FDA approval, is necessary before commercial application of dextranase can proceed.

INTRODUCTION

Dextrans, produced by the organism Leuconostoc mesenteroides in stale or freeze-damaged cane, have long been known to cause difficulties with juice clarification and pan boiling. These long-chain polysaccharides interfere with crystallization, causing the formation of needle grains, and slowing the crystal growth rate.

Dextrans can be especially troublesome if cane is not processed promptly after burning and harvesting. Warm weather is particularly conducive to activity by Leuconostoc. Similarly, when a killing freeze is followed by warm weather, cane infestation is inevitable. In Louisiana, the harvest season has always been limited by the advent of freezing weather. Historically, the freezing weather usually occurs by mid-December, (1) so that Louisiana farmers and processors aim to finish the crop by Christmas. Changes in weather patterns have also brought freezes to Florida--low temperature having curtailed the 1976-77 season there.

When cane freezes, growth ceases. No further increase in sucrose content occurs, and inversion of sucrose to glucose begins, as well as formation of acids which accelerate spoiling. These phenomena are hastened if the temperature rises substantially after a freeze. This deterioration of freeze-damaged sugar cane can be of calamitous proportion to the sugar producer. (It is probably of somewhat less concern to the alcohol-producer since invert sugars are desirable fermentation feeds, anyway).

If the freeze is hard enough to split the cane stalks, an open door is provided for invasion of Leuconostoc. This bacterium is ubiquitous. It is present in cane fields and in factories, and is eager to feed on sugar where it can find it. The microbe produces dextran, a long chain polysaccharide of variable molecular weight, reaching perhaps 5 million. Dextran is a slimy, stringy polymer that thickens the sugar juice and can upset all the raw sugar processing steps--especially crystallization. When dextrans build up in sugar syrup, the sugar boiler encounters fine, needle-shaped, slow-growing sugar particles instead of the usual beautiful cubic sugar crystals. When this happens, the sugar mill has up to now had no recourse but to dump the batch.

What difficulty dextran will cause a fermentation plant is not known--but because of its undesirable physical properties, it is presumed to be undesirable there, too.

Recent Australian literature (2,3,4,5) describes lab and factory trials of the enzyme, dextranase, as first suggested by Tilbury (6). Dextranase specifically attacks the 1-6 linkages of the glucosidic chain, breaking the polymer down mainly into isomaltose and isomaltotriose (7). Depolymerization restores the physical properties of the juice or syrup, which can then be processed as usual. A preliminary trial of this interesting enzyme was made at Audubon Sugar Institute during the fall and winter 1977-78, as described in the following paragraphs.

MATERIALS

Sugar cane used in these tests was variety CP65-357 supplied by the Sugar Experiment Station of Louisiana State University. Dextranase (Novo 25L) was supplied as a gratis sample by Novo Industries of Denmark. It is produced biochemically from the mold penicillium.

TESTS ON STALE CANE

Three materials were studied: "fresh" cane (actually 5 days old), stale cane (19 days old) and dextranase-treated syrup from stale cane. These materials were all ground in the Audubon Sugar Factory tandem. The juice was limed, heated, treated with Separan, and clarified in open defecators. A single-stage pilot vacuum evaporator was used to boil the juice to syrup.

Sugar was easily prepared ("A" strike) from syrup from the "fresh" cane. The 5-day delay after harvesting apparently resulted in no significant deterioration, thanks to cool weather. The crystals formed were cubic and boiling was normal.

A portion of the fresh cane described above was kept in the cane yard for an additional 14 days. The average high temperature during this period was 71°F. The average low was 55°F. The overall average temperature was about 63°F. Under these conditions, the cane went stale. For example, it took about 2½ pounds of lime per ton of cane to neutralize the juice, and the purity dropped 9-10 points.

Attempts to boil the syrup from this stale cane were, as expected, unsuccessful. In concentrating the syrup, strings and gum balls formed in the pan. Pan seeding was difficult, and the crystals grew too slowly to be practical. Many of the crystals were needle-shaped (Fig. 1). They gave difficulty in the centrifuge, with many of them passing through to the molasses (Fig. 3). This operation had to be aborted.

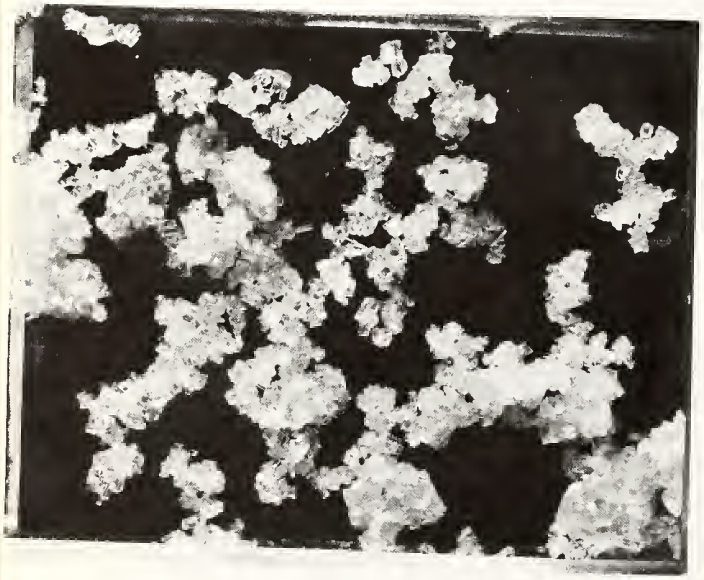

Figure 1. Fine, elongated crystals from sour syrup.

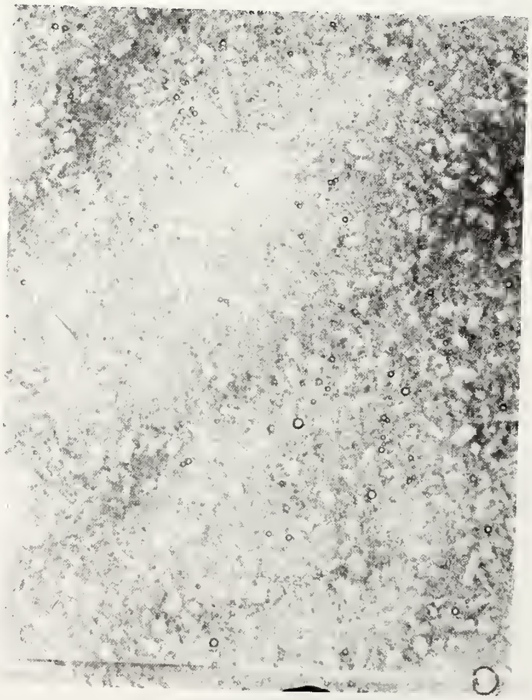

Figure 3. Molasses from sour syrup, showing fine, needle-shaped crystals.

Dextranase Treatments

Recommendations for treating conditions are contained in the original Australian articles by Inkerman et al (2,3,4,5) and in the literature provided by the dextranase supplier, Novo Industries (7). Four different dextranase treats were made on the "stale" syrup described above. The recommended and actual ranges of treatment are summarized below:

DEXTRANASE TREATMENTS

	RECOMMENDED		USED
	JUICE	36° BRIX SYRUP	36° BRIX SYRUP
Dosage, gms/1000 li.	10-20	35-70	100-200
Time, mins.	15-30	30-60	60-480
Temp. °F.	130-140		130-140
pH	4-6		6.2

According to Inkerman et al (2) it is preferred to treat the unlimed juice with a dosage of 10-20 grams of dextranase per 1000 liters of the juice for 15-20 minutes at a temperature of 130-140°F and a pH of 4-6. For a number of reasons we elected to use a more concentrated material of 36° Brix. The treatment doesn't work well at much higher concentrations. At 36° Brix, the dosage recommended is about 35-70 grams/1000 liters. The reaction rate is lower at the higher concentration so a treating time of 30-60 minutes is recommended at the same temperature and pH. The treatment used was much more severe, as shown. We used 100-200 grams/1000 liters of dextranase and times ranging from 1 to 8 hours. The temperature was in the recommended range; and although the pH was somewhat higher, it should be operable according to data on hand. The high severity of treatment was intentional. We wanted to be sure to use enough dextranase to give the technique the best chance of working. Also, our 19 day old cane was very badly deteriorated, compared to the 2 day old chopped cane used in the Australian research.

After dextranase-treating the syrup, we were able to boil sugar successfully, without trouble from gum balls or needle-grain. In Figure 2, typical crystals are shown. Pan seeding was normal. Crystal growth rate, though not quantitatively measured, was apparently lower than with fresh material. This was not unexpected in view of low syrup purity. But the point is that without the dextranase treatment, the syrup was totally unmanageable.

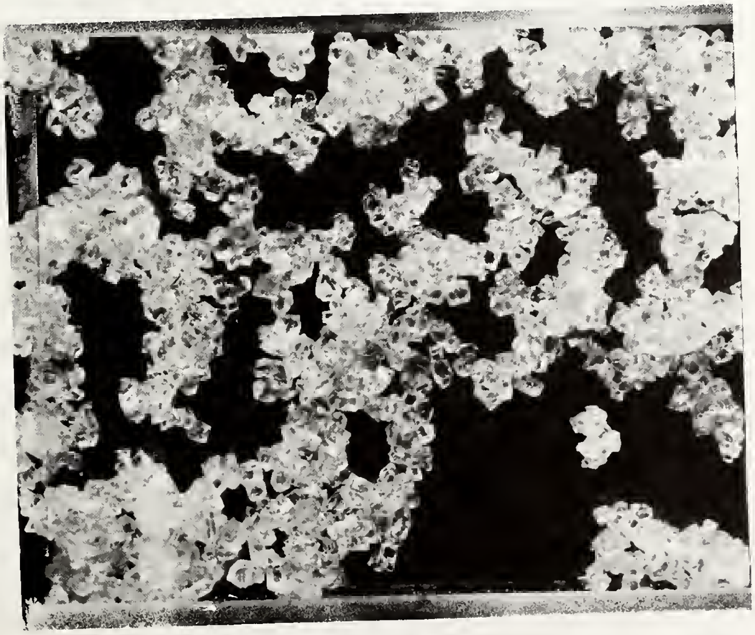

Figure 2. Normal crystals from dextranase-treated syrup.

All of the syrup treatments tried at 140°F worked. The first three trials were at a dosage rate of 200 grams/1000 liters (compared to 35 to 70 recommended). In the first run, the treatment time was 8 hours. Crystals from this run are shown in Figure 2. On the subsequent runs, we cut down on the severity of the dextranase treatment. First, time was reduced to 2 hours, then to 1 hour. Finally, we made a test at 2 hours with half the dosage. In all cases, the dextran content was reduced low enough to permit good crystal growth.

TESTS ON FROZEN CANE

The Baton Rouge area encountered freezing weather in early December, 1977. Several dips below 32°F, of 1-5 hours duration, occurred in December and early January. From January 9 to the middle of February, freezes occurred almost daily, with the temperature rarely exceeding the 40's.

A complete temperature log for the period in question is shown in Table 1.

With the cooperation of the L.S.U. Sugar Experiment Station, cane was left in the field during the entire period. The tops were "nipped" by the earlier freezes, and by December 22 all tops were killed. After the hard freezes of January 9-10, all the cane was considered dead.

On January 5, and every few days thereafter until February 22, small (100 lb.) samples of this cane were cut and supplied to Audubon Sugar Institute for tests.

These samples were ground in a small Farrel sample mill--a 3-roll mill--one-pass grinding only, with no added water. Thus the juice extracted was similar to crusher juice in a mill, and not necessarily representative of total extraction. Analyses of these sample juices are shown in Table 2.

It is surprising how little deterioration occurred in this cane long after it was dead. This preservation is attributed to the absence of high ambient temperatures which certainly would have accelerated degradation. But January and February were unusually cold for Baton Rouge just as they were for most of the U.S. Anyhow, as late as the third week in February, some samples were still showing juice purities in the 80's, with apparently low acidities and low glucose formation.

Nonetheless, by the latter part of February, deterioration was evidenced by some drop in purities, and by increases in glucose ratio and acidity. (Unfortunately, no analyses for dextran content were made.)

On February 13, a 3-ton sample of cane was cut and burned, and ground in the Audubon mill on February 14 (Run 77-24 - Table 2). Syrup was brought to the sugar boiling vacuum pans on February 15. Attempts at graining and crystal growth were unsuccessful. Gummy strings and lumps, characteristic of high dextran content, formed as the syrup was concentrated. Only a few fine needle-shaped sugar crystals could finally be formed, and the run was aborted.

Dextranase Treatment

The mass from the above operation was rediluted to about 36° Brix, heated to 131°F and treated with 200 ppm of dextranase. The syrup (pH - 6.8) was held at these conditions for 1½ hours, and returned to the vacuum pan for boiling. This time it was successfully grained, and satisfactory sugar crystals were formed. However, crystal growth rate again appeared somewhat lower than normal.

CONCLUSION

These preliminary experiments have confirmed beyond doubt the technical feasibility of using dextranase to combat the adverse effects of dextrans. Dextranase has the potential of extending the Louisiana harvest season significantly. If cane can be harvested in January and February, then considerably higher tonnages should be producible. Further, use of dextranase, if perfected, should provide a way to process juice from otherwise unsatisfactory, deteriorated cane. This possibility is clearly indicated for sugar production, and it should also apply if the juice were to be fermented to alcohol.

But further research is needed before dextranase is fully ready for commercial use. The primary need is to obtain FDA approval. Suppliers may be reluctant to commit resources to tedious procedure of gaining approval, especially with the outlook for a limited ultimate market. Work will continue with suppliers to try to overcome this obstacle. Other research needs are:

1. Establish minimum dextranase requirements;

2. Determine molasses exhaustion possible with dextranase treated stocks;

3. Develop improved analytical techniques for the rapid determination of dextrans in juices, syrups, and dextranase-treated streams;

4. Determine optimum process point and conditions for dextranase treating.

Finally, this work does illustrate the great power of biochemistry. It also illustrates the importance of keeping up with the latest technological developments in the scientific world.

Table 1. Temperature Log
Baton Rouge Area
December 1977 - February 1978

Date	°F High	°F Low	Hours Below 32°F
December 1, 1977	62	47	
2	68	47	
3	76	56	
4	80	61	
5	71	51	
6	45	31	1
7	49	28	4
8	63	42	
9	59	44	
10	41	26	6
11	49	27	5
12	64	36	
13	56*	44(40)*	
14	59*	44*	
15	52*	35*	
16	42*	24*	
17	37*	18*	
18	37*	27*	
19	39*	16*	
20	50	38	
21	40	32	
22	46	27	3.5
23	58	38	
24	65	56	
25	60	32	
26	44	26	5.5
27	48	26	
28	36	32	
29	45	36	
30	50	45	
31	59	45	
January 1, 1978	54	41	
2	40	29	2
3	41	27	2
4	53	24	4
5	60	38	
6	63	51	
7	64	54	
8	55	32	
9	32	22	24
10	28	22	24
11	40	28	5.5
12	42	33	
13	35	30	7
14	30	25	24
15	36	21	21
16	54	30	5
17	45	26	8
18	29	26	24
19	35*	30*	
20	29	27	24
21	33	26	20

Table 1 (cont'd)

Date	High	Low	Hours Below 32°F
January 22, 1978	36	30	4.5
23	42	33	
24	52	43	
25	51	32	
26	36	24	7
27	35	24	21
28	37	29	19
29	44	23	5.5
30	57	34	
31	39	34	
February 1, 1978	42	35	NA
2	44	39	NA
3	42	37	NA
4	45	31	NA
5	52	31	NA
6	52	28	NA
7	46	29	NA
8	41	32	NA
9	49	31	NA
10	48	31	NA
11	51	31	NA
12	59	39	NA
13	64	47	NA
14	64	32	NA
15	51	31	NA
16	49	35	NA
17	62	37	NA
18	61	36	NA
19	39	31	NA
20	42	25	NA
21	57	29	NA
22	42	21	NA

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*From Baton Rouge Weather Station at Ryan Airport. All others from St. Gabriel, Louisiana.

Table 2
Data on Frozen Cane - Sample Mill Juice
Variety 65-357

Date	No.	Brix	Pol	Apparent Purity	Glucose	Glucose Ratio	Titratable Acidity	Total Sugars (Dry Basis)
1-5-78	77-14	------	-----	------	-----	-------	-----	-------
1-10-78	77-15	16.98	14.20	83.63	0.44	3.10	3.4	87.16
1-16-78	77-16	16.38	13.73	83.83	0.62	4.52	3.4	88.22
1-23-78	77-17	18.92	15.94	84.25	0.74	4.64	3.2	88.16
1-26-78	77-18	14.04	10.30	73.36	0.97	9.42	4.3	82.40
2-2-78	77-19	18.6	16.24	87.31	0.62	3.82	2.2	90.64
2-3-78	77-21	19.79	16.1	81.35	1.57	9.75	3.3	89.28
2-8-78	77-22	16.27	12.6	77.44	1.26	10.0	3.8	85.18
2-13-78	77-23	18.49	15.0	81.12	1.05	7.0	4.2	86.8
2-14-78	77-24[a]	16.92[b]	12.9[b]	76.24[b]	1.35[c]	13.24[c]	4.3[b]	82.8[c]
2-21-78	77-25	20.6	17.4	84.47	1.06	6.09	2.6	89.61
2-22-78	77-26[a]	17.16[b]	12.0[b]	69.93[b]	1.89[c]	19.69[c]	5.8[b]	79.34[c]

a) Run 77-24 in large Audubon Mill; also Run 77-26.

b) Crusher juice sample large mill.

c) Mixed juice from large mill.

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LIST OF FIGURES

DYNAMICS OF pH CONTROL IN THE SUGAR HOUSE

Fernando Z. Llorens
United States Sugar Corporation
Bryant, Florida

ABSTRACT

In raw sugar manufacturing, the clarification process is a critical step of production, the outcome of which is crucial to the success of subsequent operations. For any process, there are a variety of physical conditions which possess optimum value for both simplicity and economy. One of these conditions is the addition of lime to the juice by means of automatic process control. Proper determination of this control problem is achieved by undertaking a study of the characteristics of the control loop. These characteristics are: the load changes of the process; the dynamics of process reaction rates, and the variety of lags present in the control loop. It is the interplay of these factors that will determine the difficulty or effectiveness of any control system. A study such as this was conducted at Bryant Sugar House during the 1977-1978 crop. The findings during this study helped the Sugar House tailor its control functions to achieve a high degree of quality control on its liming operations and make its process more responsive to Sugar House demands.

INTRODUCTION

In raw sugar manufacturing the primary objective of clarification is the removal of impurities from the juice at the earliest stage possible. The mill juices which reach the clarification stage arrive as a complex mixture of matter extracted throughout the crushing and washing operations of the mill tandems. In the basic clarification process the mill juices are treated with lime and heated to a temperature of 210° to 220° F, prior to evaporation. The principle objectives of this process have caused considerable amounts of disagreement and study. To this day, limited knowledge is available as to what the most satisfactory reactions should be. Various amounts of stress have been laid on such concepts as purity, prevention of juice inversion, removal of non-sugars, and the elimination of colloids. However, basic importance must be attached to the necessity of raising the pH of the raw juice to a point near or above neutrality where the sucrose inversion in subsequent operations is minimal. The basic reagent used to achieve this purpose is lime. Lime is cheaply obtained and is also quite helpful in the removal of certain constituents from the juice which prove troublesome in later stages of the recovery process. For any process there are certain physical conditions which have optimum values for both simplicity and economical operation. The addition of lime through means of automatic process control is the main objective of this paper.

The automatic pH process control is accomplished by continuously sampling the juice for its hydrogen-ion activity and automatically adding a milk of lime solution so as to maintain a desired pH in the resultant mixture. The value of this pH is usually maintained so as to produce a resultant pH of 6.8 to 7.0 in the clarified juice. Proper control of composition variables, such as pH, is difficult upon certain circumstances due to the fact that requirements vary with process parameters.

Determination of the task of this control problem depends on the characteristics of the control loop. This loop includes the process, the measuring means, the controller, and the regulating mechanisms. The controller mode of action is directly governed by the dynamics of the process. These are sometimes modified to make the control task simpler. The major dynamics of the pH control system in the sugar house are:

(A) The changes and disturbances which arrive from sources external to the system; these are known as load changes. In the process under consideration these arrive as changes of incoming flow rate or changes in the quality of the milk of lime.

(B) The reaction rate; this is the dynamics of the chemical reactions between the juice and the milk of lime solution.

(C) Time lags; these present themselves in three types: measurement, controller, and system transfer lags.

(D) Dead time; this can exist in any portion of the system and it is to be distinguished from the previously mentioned lags in that it consists in an actual physical delay rather than a retardation of the control means.

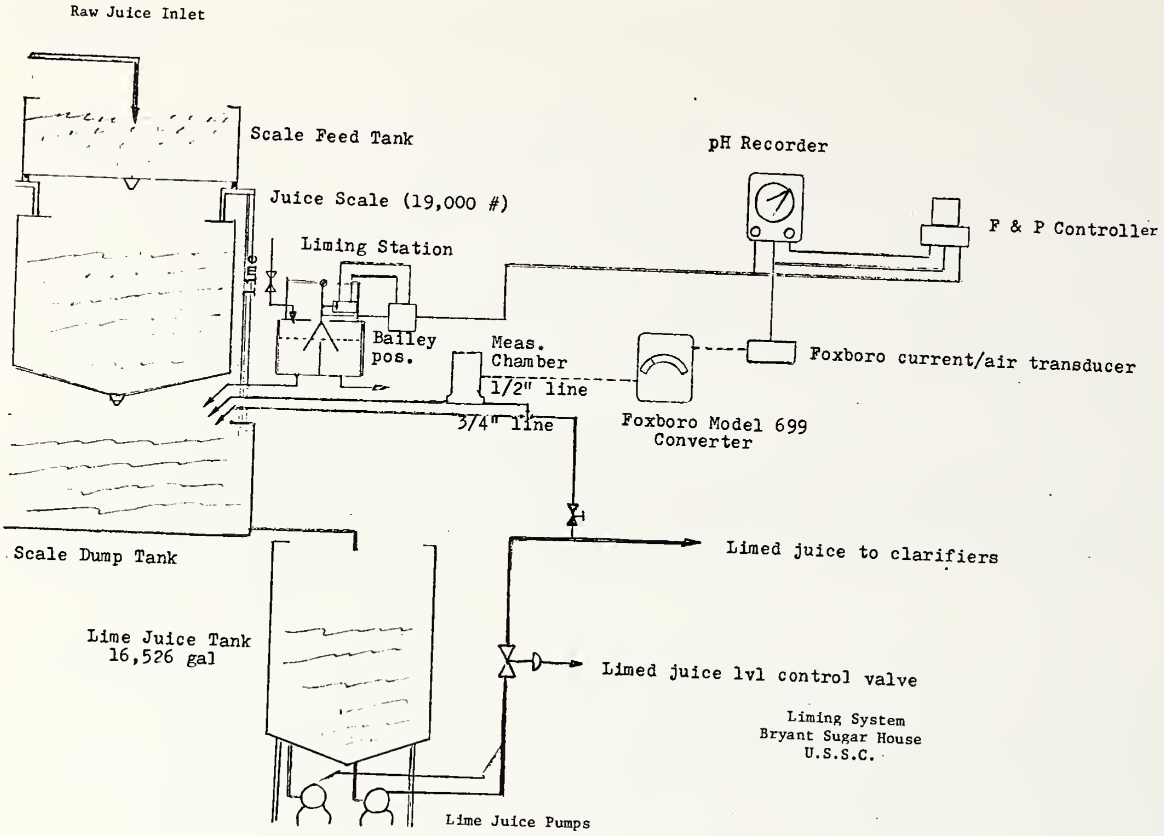
The difficulty of any control system is an interplay of the forementioned factors and it is their presence and interreaction which determine the most appropriate mode of control to be used. If, for example, time lags and dead time are unavoidable dynamics of a system, then it is desirable that the load changes be gradual and reaction rates be slow. Dead time is highly detrimental to any control system since it causes uncontrollable delays between changes in the control medium and the actual effect of the correcting action. The major detrimental effects of time lags are that of slow responses, rather than delayed responses. Extensive literature is available on the subject of process control and means of arriving at modes of controller settings for various types of processes. The following is the study of one such procedure.

At Bryant Sugar House we began the study of our process dynamics by determing the quantitative presence of the dead time, time lag, load changes, and reaction rate factors. Our first task was to reduce the time lag involved in measurement. Our goal here was to choose an electrode location which would provide a composite sample of the system's reactions and that would have a minimum amount of delay in the measurement of the process. To accomplish this, we ran a 1" sample line from the outlet of our mixing tank pump. A tee was placed on this 1" line and a ½" line was then run to our pH sample chamber (Fig. 1). The results of this configuration were very satisfactory. We achieved low fluid velocity through our chamber, thereby increasing useful electrode life. Along with this, the juice was sufficiently circulated so as to provide a highly composite sample of the process output. After comparing the performance of our new sampling system with the old restricted flow system previously used, we found that we had cut the sample time lag by better than one-half. Our controller reaction was also quicker and smoother.

Another factor which affects the pH process is the buffering action of the juice and its initial pH value. The neutralization curves of pH are by no means linear and their nonlinearities are proportional to the buffering action of the reagents. Cane juices contain many impurities affecting neutralization curves and their process load. Process load is defined as the amount of reagent required for proper neutralization. It is proportional to the volume (tank level) and the initial pH of the juice. Since buffering will directly affect the slope of the neutralization curve and the amount of reagent required, the extent of this is best determined by performing a titration and determining the juice's sensitivity to reagent addition. The results are then plotted graphically. Since a procedure of this sort would be very tedious in a large scale experiment, we ran laboratory tests on 500 ml samples of mixed and crusher juices. We titrated these samples with milk of lime solutions ranging in Baume' from 5° to 11° and plotted the average results into a general reaction curve. Our reason for this was to allow for the discontinuity in the consistency of the milk of lime supplied to the process. This is not a highly quality controlled procedure in most sugar houses. (Fig. 2). As can be seen by these test results, the juice has a low buffering action and the reaction curve throughout the portion around the normal operating point is nearly linear and could be expressed in terms of a linear equation. This equation could be in the form of $y = mx + b$, where y is the required pH expressed in terms of the variable x which is the lime flow and m which is the slope of the reaction curve. The intercept, b, is expressed by the initial pH of the raw juice. For example, from the averaged standardized curve resulting from our titrations we found that to raise the pH of the juice from 5.5 to 7.5 ± .25 pH we would need to control our milk of lime flow to an accuracy of ± 5.5%. At Bryant Sugar House the additions of the milk of lime to the process is accomplished by the splitter-box method. A y-shaped paddle is positioned by an air activated cylinder. Motion and position of the paddle is transmitted to a Bailey Meter Company positioner by a zero-lash adjustable linkage. Our choice of a Bailey positioner enabled us to program the response of the paddle according to our resultant equation by designing cams which position the paddle to provide the required milk of lime flow according to the process requirements.

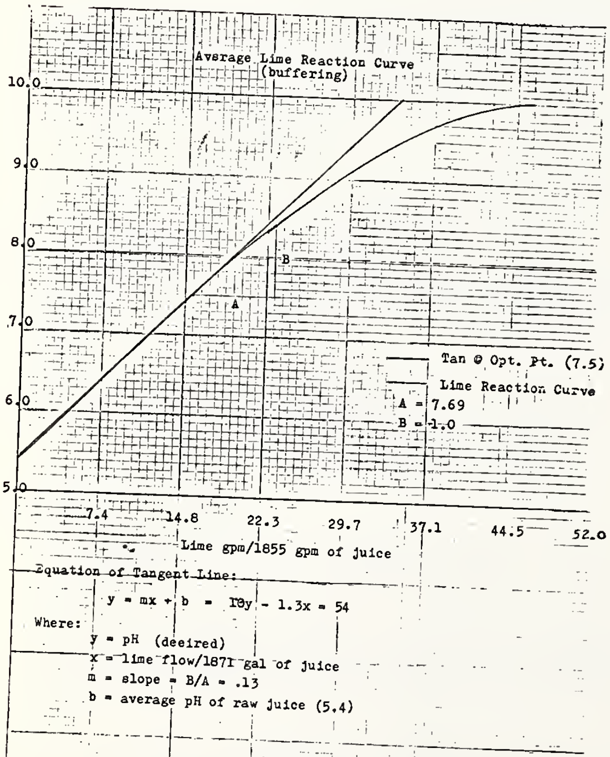
A third factor involved was that of retention time and proper mixing. Although this was beyond the control of our pH controller, it was a direct influence upon the instrument's performance. Due to the nature of our process, the retention time variable is a direct function of the plant's load and tank level. Unfortunately for control purposes, this is not always constant. We took samples of time constants for our process at various tank levels and composed an average process reaction curve. (Fig. 3) From this process reaction curve, by the use of the Ziègler and Nichols method of graphical analysis, we estimated our components of lag, reaction rate, and unit reaction rate. Based on these results we calculated the required gain and integral functions of the controller. After setting the controller to the calculated functions, it was subjected to a variety of load changes. We found that the controller reacted very well to these changes and that return to set point and set point offset were minimal. We then proceeded to make further studies of our process time constants. These tests were conducted during normal grinding activity and the various load factors were introduced as normal system disturbances. The combined results of the valve adjustment based on the titration experiments and on the new controller adjustments gave us excellent results. Our pH charts show exceedingly good control of ± .2 pH units under a wide variety of load conditions.

Due to the nature of the sugar making process, juice flow can widely vary at given times. If good process control is to be maintained to a given accuracy, the rate times of our controller would have to change constantly to suite these changing conditions. This is highly improbable. The best solution we could find for this problem was to take an average hourly grinding rate based on previous yearly records. this rate was established as the norm for our process control load. (Table 1) Based on these conditions we projected operating points on our graphs and based our entire process dynamics upon these values. As mentioned before, excellent response was obtained. Gain and reset values were very accurate throughout most load changes. Set point return was quick, offset was small and we encountered minimal overshoot of our reset responses.



Liming System
Bryant Sugar House
U.S.S.C.

Figure 1



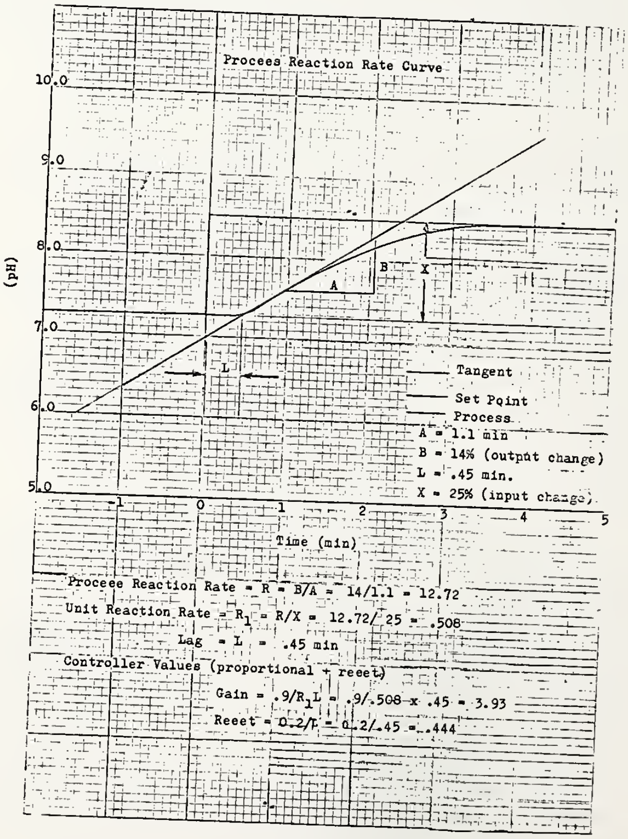
Equation of Tangent Line:

y = mx + b = 10y - 1.3x = 54

Where:

y = pH (deeired)
x = lime flow/1871 gal of juice
m = slope = B/A = .13
b = average pH of raw juice (5.4)

Figure 2



Proceee Reaction Rate = R = B/A = 14/1.1 = 12.72

Unit Reaction Rate = R_1 = R/X = 12.72/ 25 = .508

Lag = L = .45 min

Controller Values (proportional + reeet)

Gain = .9/R_1L = .9/.508 x .45 = 3.93

Reeet = 0.2/L = 0.2/.45 = .444

Figure 3

At this time it would be appropriate to mention a variety of conditions over which our control system was inappropriate. During those times when the grinding is stopped and there is no subsequent juice flow the system can become highly unstable. This is due to the fact that it acquires the characteristics of an end-point batch type control. This type of control system can not tolerate the normal integral response of the pH controller. Overshoot is unavoidable and if proper control is desired a reset override P.D. controller is necessary. Since juice flow is zero at this time, the controller can do no more than to fully close the valve but by this time overshoot has already occurred and the condition will not be remedied by this action. Another variation of control available which is quite efficient for this type of process is that of feedforward control in combination with the conventional feedback controller. This system, if properly tuned, is a powerful control tool for composition type systems. The feedforward section of the system dampens the changing load conditions while the regular feedback section does the normal control function but with one-half the workload.

In closing I would like to say that although composition systems are by no means the most difficult type encountered, their degree of difficulty rises with the complexity of their sampling systems. The sampling system introduces the major dynamic of dead time. The time constant of the system is expressed as the volume/thruput ratio of the mixing vessel provided that there is perfect mixing. With no mixing or surge vessel (low tank level) the dead time would be the dominant lag. However, most normal systems have some degree of mixing and therefore both dead time and capacity lags are present. Under these conditions the sum of these lags is the equivalent of the system's volume/thruput and the dominant lag is dependent upon the degree of mixing. Note that since both of these lags are flow dependent the accuracy of our control will depend upon the load conditions about which the controller is tuned. Therefore our control function will constantly react to the sugar house demands.

Table 1. Average Process Data*

Hourly grind -- 548 tons/hr x 2000 lbs/ton =	1,096,000 lbs/hr
Imbibition water @ 14.90% cane =	163,304 lbs/hr
Total cane and water =	1,259,304 lbs/hr
Bagasse @ 25.10% cane =	316,085 lbs/hr
Total diluted juice =	943,219 lbs/hr
Average brix of juice =	15.77% suc. by weight
Weight of juice @ 15.77 brix =	8.40 lbs/gal.
Flow = 943,219 lbs/hr / 8.40 lbs/gal. =	112,288.0 gal/hr
Flow$_2$ gpm = 112,288.0 gal/hr / 60 min/hr =	1,871.0 gpm

Load Example:

Capacity of juice tank = 16,526 gal @ 35% lvl = 5784 gal

Juice flow = 1871 gpm

Lime flow = 15.54 gpm (based on data from figure 2)

pH = 7.5 T = v/f = 5784/1871 = 3.09

Assume level drop to 20% --- level = 3305 gal (output flow increase 15%)

New juice flow = input = 1871 gpm output = 2151 gpm

Tank will reach level of 20% in 8.85 min. New lime flow increase to 17.87 gpm. Flow returns to 15.54 gpm. T = v/f = 3305/1871 = 1.76.

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*data based on average hourly grind, '76-'77 crop.

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A COMPARISON OF RAW SUGAR BOILING SCHEMES

Harold S. Birkett
F. C. Schaffer & Associates, Inc.
Baton Rouge, Louisiana

ABSTRACT

This paper presents a rigorous method for calculating the material and steam balance for various sugar boiling schemes. Examples are given for:

1. The conventional three boiling system
2. The two boiling (A-C) system
3. The double einwurf system

The results from the material and steam balance can be used to compare these systems with regard to:

1. The pan requirement
2. The centrifugal station requirement
3. The exhaust (or vapor) requirement
4. The condenser water requirement
5. The controllability of purities
6. The ease of graining

ASSUMPTIONS

These are listed in Table 1.

DISCUSSION OF RESULTS

Pan Requirement: From a knowledge of the massecuite volumes and the strike boiling times, the pan capacity requirements can be calculated. The massecuite volumes are presented in Figures 1, 2 and 3 are summarized in Figure 4. The boiling times for the strikes for the different schemes will vary somewhat. The A strikes for the double einwurf massecuites will take less time to boil because of the large footings used.

The pan capacity requirements for the three boiling and two boiling systems are approximately equal, while the pan requirements for the double einwurf are about 10% greater.

Centrifugal Requirement: The production of "C" massecuite is constant for all boiling systems. The production of high grade massecuite is lowest for the two boiling system. The high grade massecuite production in the case of the three boiling system is about 6% greater than that of the two boiling. The quantity of high grade massecuite produced by the double einwurf system is about 50% greater than that from the two boiling, and about 45% greater than that from the three boiling system. This is a result of the double centrifugalling of the "B" sugar.

Exhaust Steam Requirement: The steam requirements for the various boiling schemes is shown in Figure 5. The steam requirement is lowest for the two boiling system, followed by the three boiling system where steam requirement is 7% greater than that of the two boiling, followed by the double einwurf system's steam requirement which is 23% greater than that of the two boiling system.

Condenser Cooling Water Requirement: The pan condenser water requirement closely parralels the steam requirements. The double einwurf system requires about 20% more water than that of the other two systems.

Control of Purities: In the two boiling system the "A" molasses purity must be controlled so that the C massecuite can be maintained at its optimum level. This necessitates close control of the "A" massecuite purity by recycle of "A" molasses to the "A" strike.

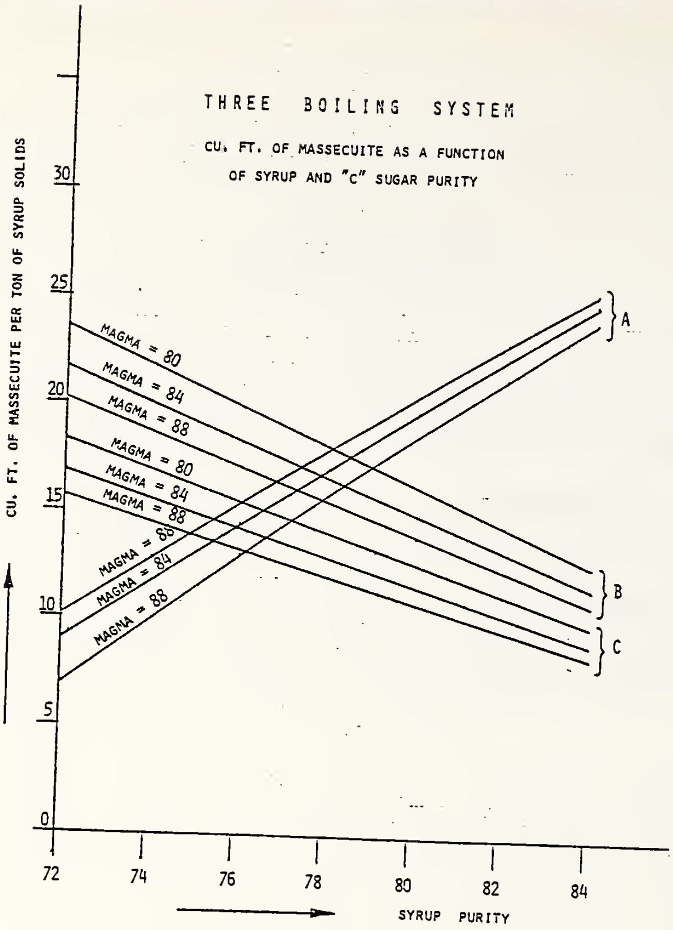


Figure 1

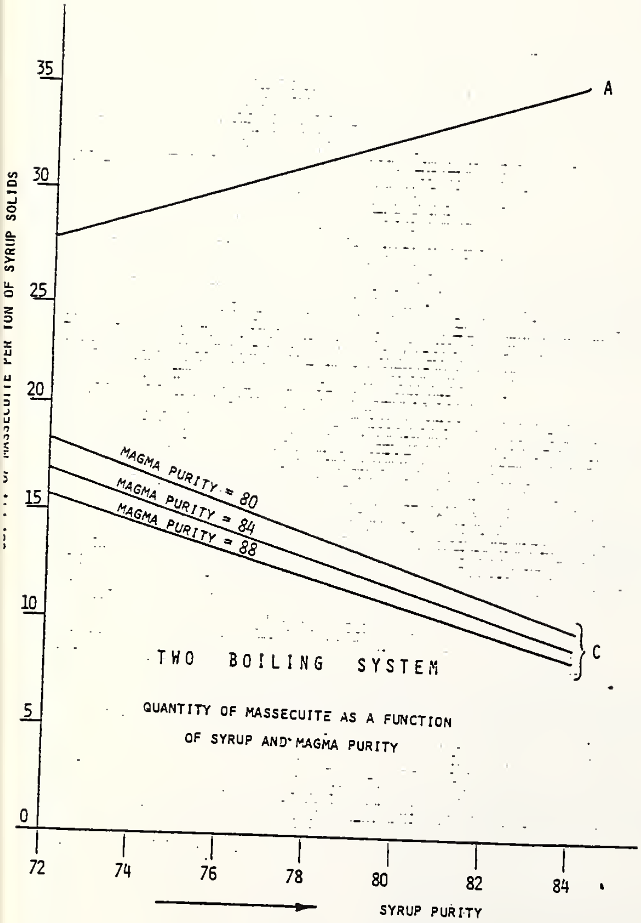


Figure 2

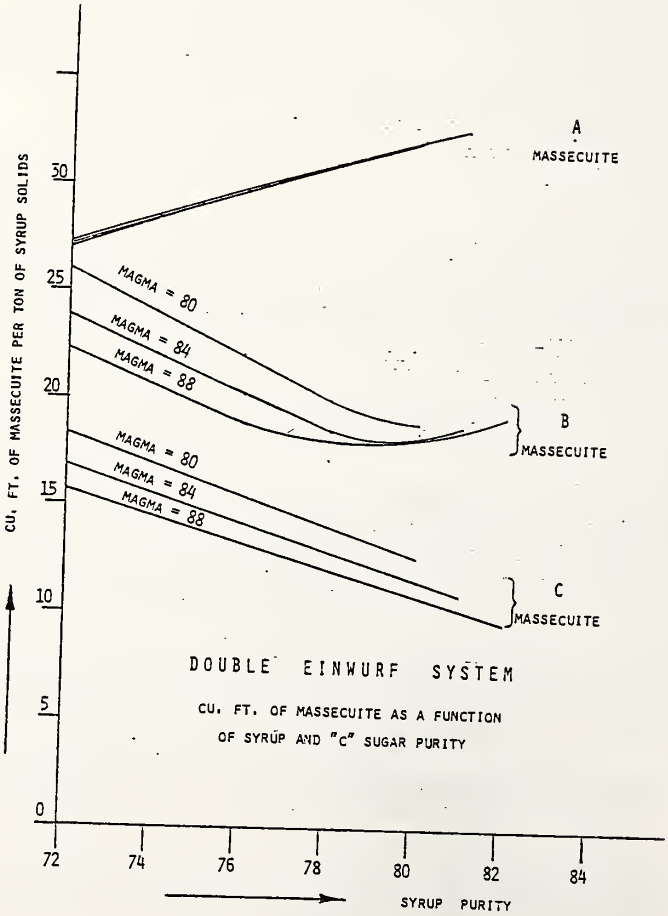


Figure 3

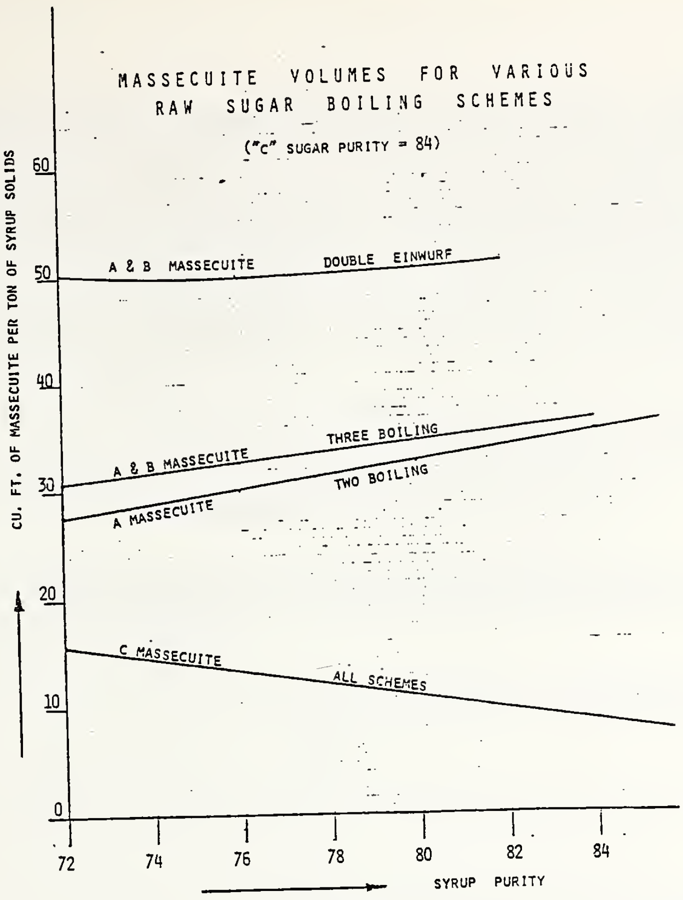


Figure 4

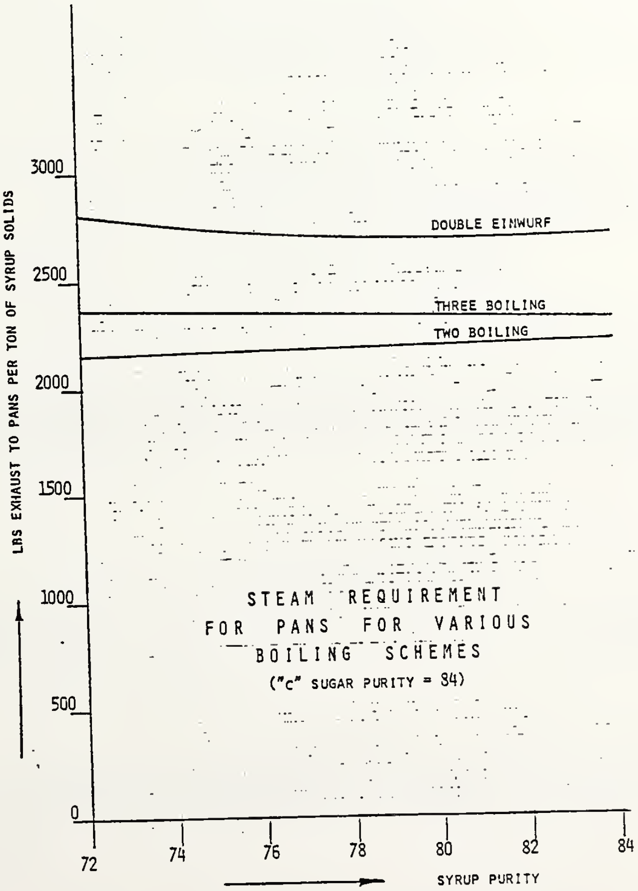


Figure 5

In the three boiling system less control of the "A" strike purity is required since the grain strike purity can be varied as required. B massecuite purities are readily controllable.

In the double einwurf system the control of strike purities is more difficult than that of the three boiling system. The large volume of the "B" sugar going to the "A" strikes makes the "A" massecuite purity increase rapidly as the syrup purity increases. The large quantity of "C" sugar going to the "B" strike also makes the "B" strike purity increase rapidly at high syrup purities.

Ease of Graining: Graining in the three boiling and double einwurf schemes on a 70 purity material is quite easy. Graining "A" molasses at under 60 purity as is required for the two boiling system can be difficult.

Range of Application: The two boiling system can operate on syrup purities up to 78-80 before the recycle of "A" molasses to the "A" strike is necessary.

METHOD FOR MATERIAL BALANCE SOLUTION

The method of solution will be described in detail for the three boiling system. The principles used in the solution of the three boiling scheme can be readily applied in the solution of other boiling schemes:

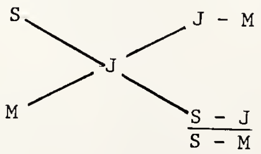
The data required is as follows:

	Brix	Purity
Syrup	X	X
Sugar	X	X
"A" Massecuite	X	not required
"B" Massecuite	X	X
"C" Massecuite	X	X
Grain	X	X
Magma	X	X
A Molasses (Diluted)	X	X
B Molasses (Diluted)	X	X
Final Molasses (Diluted)	X	X
Total pounds of syrup solids handled.		

Before describing how the calculations are performed, a thorough understanding of the SJM formula is required. Expressed in words, the formula says that given a juice (or initial material) of J purity and producing a sugar of S purity with a molasses of M purity, the percentage of the total pol in the original material which will go into the sugar will be

$$100 \times \frac{S(J - M)}{J(S - M)}$$

The above formula does not take into account any losses. Another useful formula is the Cobenze Diagram for calculating mixtures:



Here the quantities S, J, and M have the same meaning as in the SJM formula. In this formula, the ratio of sugar solids to molasses to juice solids are in the ratio of J - M to S - J to S - M. The Cobenze Diagram can thus be used to solve for the ratio of solids in streams given the purities.

In solving the three boiling system the following calculations are performed.

1. The syrup entering the pan floor is ultimately separated into sugar and final molasses. The SJM formula can be applied to these streams to find the pol in final molasses by applying the SJM formula to the pol in syrup.

2. The solids (Brix) in final molasses can be obtained by dividing the pol in final molasses by the final molasses purity.

3. Knowing the purities of the "C" Massecuite, "C" Sugar, and final molasses and the quantity of final molasses, the Cobenze Diagram can be applied to find the solids in the "C" massecuite, and the "C" Sugar. The pol in the "C" Sugar and "C" massecuite can be obtained by multiplying the solids by the purity.

4. Knowing the Grain, "B" Molasses, and "C" Massecuite purities together with the solids in the "C" Massecuite, the solids in the Grain and "B" molasses can be obtained using the Cobenze Diagram. From the solids in the Grain and "B" molasses and their respective purities the pol in the Grain and "B" molasses can be obtained.

5. The grain strike is composed of syrup and "A" molasses. Knowing all the purities and the solids in the grain strike the solids in syrup and "A" molasses can be obtained using the Cobenze Diagram, while the pol can be obtained from the solids and the respective purities.

6. The "B" massecuite and "B" sugar solids (from the B strike) can be calculated knowing the purities and the "B" molasses solids. The pol in the "B" sugar and "B" massecuite can be obtained from the respective solids and purities.

7. In steps 1 and 2 the final molasses pol and solids were determined. The total pol and brix in the "A" and "B" sugars can be obtained by subtracting the final molasses pol and solids from the pol and solids in the syrup. The pol and solids in the "A" sugar can be obtained by subtracting the pol and solids in the "B" sugar from the pol and solids in the total "A" and "B" sugars.

8. If it is desired to make the same size sugar crystal from the A and B sugars, then the magma produced from the "C" strike should be divided between the "A" and "B" strikes in proportion to the quantity of A and B sugar.

9. The total of syrup and "A" molasses solids and pol used on the "B" strike is obtained by subtracting the solids and pol in the magma used on the "B" strike from the solids and the pol in the "B" massecuite. The average purity of the syrup and "A" molasses fed to the "B" strike is calculated, and then using the Cobenze mixing diagram the quantity of solids in the syrup and "A" molasses feed to the "B" strike are calculated individually. The pol in the syrup and "A" molasses feeds to the "B" strike are calculated individually.

10. The pol and solids in the "A" molasses produced in the "A" strike is obtained by adding up the "A" molasses pol and strikes used in the "B" and grain strikes.

11. The pol and solids in the "A" strike is obtained by adding up the "A"sugar and "A" molasses.

12. The syrup required for the A strike is obtained by subtracting the syrup used in the "B" and grain strikes from the total syrup. This completes the pol and solids balance for the boiling system.

13. The lbs. material for each stream are obtained by dividing the solids by the Brix.

14. The evaporation in each strike is obtained by the difference of the total feed and the quantity of massecuite.

15. The exhaust requirement for each strike is obtained by multiplying the evaporation for each strike by the assumed pan factor.

Note: If crystal yield from each strike rather than molasses purity is the desired criterion, then the molasses purities required to achieve these yields should be recalculated and used as the starting purity assumptions for a second iteration. This process can be repeated until the desired accuracy is achieved.

Table 1

ASSUMPTIONS

1.	SYRUP BRIX	60
2.	DILUTED A & B MOLASSES	65
3.	SUGAR POL	97.6
4.	FINAL MOLASSES PURITY	30
5.	GRAIN PURITY	
	TWO BOILING	57.5
	THREE BOILING	70
	DOUBLE EINWURF	70
6.	CRYSTAL YIELD, %	
	A STRIKES	50
	B STRIKES	42
	C STRIKES	39
7.	B MAGMA PURITY	93
	(DOUBLE EINWURF ONLY)	

Table 2

STRIKE COMPONENTS FOR VARIOUS BOILING SCHEMES

BOILING SCHEME	A	B	C	GRAIN
Two Boiling	C Sugar Magma Syrup A Molasses	-	Grain A Molasses	Syrup A Molasses
Three Boiling	C Sugar Magma Syrup	C Sugar Magma Syrup A Molasses	Grain B Molasses	Syrup A Molasses
Double Einwurf	B Sugar Magma Syrup	C Sugar Magma Syrup A Molasses	Grain B Molasses	Syrup A Molasses

Table 3

COMPARISON OF BOILING SCHEMES

Boiling System	Advantages	Disadvantages
Two Boiling	Good up to Syrup Purities of 78-80	Difficult to Control C Massecuite Purity Requires Boiling Back A Molasses at Normal Syrup Purities Difficult to Grain at Low Purity
Three Boiling	Easy Control of Strike Purities Handles High Syrup Purities Without Boiling Back	
Double Einwurf	Produces Better Quality High Grade Sugar B Strikes Easier to Boil	Cannot Handle High Syrup Purities Without Boil Back Requires About 40% More High Grade Centrifugals Requires About 15% More Exhaust Steam Than Three Boiling Scheme

TWO BOILING SYSTEM

Basis: 100,000 lb. Syrup Solids

Stream	Pol lb.	Brix lb.	Material lb.	Purity	°Brix	Cu. Ft.
"A" Strike						
Magma	23,074	27,469	31,215	84.00	88.00	
Syrup	80,000	100,000	166,667	80.00	60.00	
"A" Molasses	7,285	12,669	19,491	57.50	65.00	
Total	110,359	140,138	217,373	78.75	64.47	
Evaporation	0	0	65,048	-	-	
"A" Massecuite	110,359	140,138	152,324	78.75	92.00	1,634
"A" Sugar	72,058	73,529	73,824	98.00	99.60	
"A" Molasses (Diluted)	38,300	66,609	102,475	57.50	65.00	
"C" Strike						
Grain	10,338	17,979	20,431	57.50	88.00	
"A" Molasses	20,678	35,961	55,325	57.50	65.00	
Total	31,016	53,940	75,756	57.50	71.20	
Evaporation	0	0	20,148	-	-	
"C" Massecuite	31,016	53,940	55,608	57.50	97.00	583
"C" Sugar (Diluted)-Magma	23,074	27,469	31,215	84.00	88.00	
Final Molasses	7,941	26,471	33,089	30.00	80.00	
Grain						
"A" Molasses	10,338	17,979	27,660	57.50	65.00	
Evaporation	0	0	7,229	-	-	
Grain	10,338	17,979	20,431	57.50	88.00	223

Exhaust or Vapor Required for Sugar Boiling

Strike	Evaporation	Pan Factor	Exhaust
A	65,048	1.15	74,805
B	-	-	-
C	20,148	1.25	25,185
Grain	7,229	1.25	9,036
Total	92,425		109,026

THREE BOILING SYSTEM

Basis: 100,000 Lb. Syrup Solids

Stream	Pol lb.	Brix lb.	Material lb.	Purity	°Brix	Cu. Ft
"A" Strike						
Magma	14,032	16,704	18,982	84.00	88.00	
Syrup	54,456	68,070	113,451	80.00	60.00	
Total	68,488	84,775	132,433	80.78	64.01	
Evaporation	0	0	40,286	-	-	
"A" Massecuite	68,488	84,775	92,147	80.78	92.00	988
"A" Sugar	43,820	44,715	44,894	98.00	99.60	
"A" Molasses (Diluted)	24,667	40,060	61,631	61.57	65.00	
"B" Strike						
Magma	9,042	10,764	12,232	84.00	88.00	
Syrup	19,514	24,393	40,656	80.00	60.00	
"A" Molasses (Diluted)	19,159	31,114	47,868	61.57	65.00	
Total	47,716	66,272	100,756	72.00	65.77	
Evaporation	0	0	30,254	-	-	
"B" Massecuite	47,716	66,272	70,502	72.00	94.00	749
"B" Sugar	28,237	28,814	28,929	98.00	99.60	
"B" Molasses	19,478	37,458	57,628	52.00	65.00	
"C" Strike						
Grain	11,537	16,481	18,729	70.00	88.00	
"B" Molasses	19,478	37,458	57,628	52.00	65.00	
Total	31,015	53,940	76,357	57.50	70.64	
Evaporation	0	0	20,749	-	-	
"C" Massecuite	31,015	53,940	55,608	57.50	97.00	582
"C" Sugar (Diluted) -Magma	23,074	27,469	31,215	84.00	88.00	
Final Molasses	7,941	26,470	33,088	30.00	80.00	
Grain						
Syrup	6,028	7,535	12,559	80.00	60.00	
"A" Molasses	5,508	8,945	13,763	61.57	65.00	
Total	11,537	16,841	26,322	70.00	62.61	
Evaporation	0	0	7,593	-	-	
Grain	11,537	16,481	18,729	70.00	88.00	204

Exhaust or Vapor Required for Sugar Boiling

Strike	Evaporation	Pan Factor	Exhaust
A	40,286	1.15	46,329
B	30,254	1.15	34,792
C	20,749	1.25	25,936
Grain	7,593	1.25	9,491
Total	98,882		116,548

DOUBLE EINWURF BOILING SYSTEM

Basis: 100,000 Lb. Syrup Solids

Stream	Pol. lb.	Brix lb.	Material lb.	Purity	°Brix	Cu. Ft.
"A" Strike						
"B" Sugar Magma	37,510	40,334	45,834	93.00	88.00	
Syrup	78,117	97,646	162,744	80.00	60.00	
Total	115,628	137,980	208,578	83.80	66.15	
Evaporation	0	0	58,599	-	-	
"A" Massecuite	115,628	137,980	149,979	83.80	92.00	1,609
"A" Sugar	72,058	73,529	73,824	98.00	99.60	
"A" Molasses (Diluted)	43,569	64,451	99,156	67.60	65.00	
"B" Strike						
"C" Sugar Magma	23,074	27,469	31,215	84.00	88.00	
Syrup	0	0	0	-	-	
"A" Molasses	36,940	54,645	84,070	67.60	65.00	
Total	60,014	82,115	115,285	73.08	71.22	
Evaporation	0	0	27,928	-	-	
"B" Massecuite	60,014	82,115	87,356	73.08	94.00	928
"B" Sugar Magma (Diluted)	37,510	40,334	45,834	93.00	88.00	
"B" Molasses (Diluted)	22,504	41,780	64,278	53.86	65.00	
"C" Strike						
Grain	8,511	12,159	13,817	70.00	88.00	
"B" Molasses	22,504	41,780	64,278	53.86	65.00	
Total	31,015	53,940	78,095	57.50	69.06	
Evaporation	0	0	22,487	-	-	
"C" Massecuite	31,015	53,940	55,608	57.50	97.00	582
Magma ("C" Sugar Diluted)	23,074	27,469	31,215	84.00	88.00	
Final Molasses (as produced)	7,941	26,470	33,088	30.00	80.00	
Grain						
Syrup	1,882	2,353	3,922	80.00	60.00	
"A" Molasses	6,628	9,805	15,085	67.60	65.00	
Total	8,511	12,159	19,007	70.00	63.96	
Evaporation	0	0	5,190	-	-	
Grain	8,511	12,159	13,817	70.00	88.00	151

Exhaust or Vapor Required for Sugar Boiling

Strike	Evaporation	Pan Factor	Exhaust
A	58,599	1.15	67,389
B	27,928	1.15	32,117
C	22,487	1.25	28,109
Grain	5,190	1.25	6,488
Total	114,204		134,103

ECONOMIC STUDY OF BAGASSE DEHYDRATION

C. Frank Miller
M-E-C Company
Neodesha, Kansas

ABSTRACT

In 1973, the OPEC nations drastically raised the price of fuel oil and, since that time, the world's fuel oil consumers have found that they make better use of energy; this is especially true in the sugar industry. Recently, a great deal of consideration has been given to the dehydration of bagasse using the waste flue gases from the mill boilers as the primary heat source. The primary reason why most mills are interested in the dehydration of bagasse is the potential for increasing its value as a fuel, which thermodynamically means increasing its heat of combustion. The result of this endeavor is the reduction or elimination of supplemental fuel oil burning.

Some mills have secondary uses for bagasse, such as the production of paper, fiberboard, furfural and related products. The dehydration process does result, of course, in more bagasse being available for these important by-products. Several manufacturers now offer bagasse-dehydration systems which can reduce the moisture of the bagasse to much lower levels. This report is an economic study based on the fixed costs, operating costs and capacity of a typical rotary-drum dryer using flue gases as the primary and sole source of heat.

INTRODUCTION

In 1973 the OPEC nations drastically raised the price of fuel oil, and since that time, the world's fuel oil consumers have found they must make better use of energy. Especially, is this true in the sugar industry.

In recent months, much consideration has been given to the dehydration of bagasse using as the primary source of heat, the waste flue gases from the mill boilers. The primary reason most mills are interested in dehydration of bagasse is to increase its value as a fuel, which thermodynamically means increasing its heat of combustion. The result of this is the reduction or elimination of supplemental fuel oil burning. Some mills have secondary uses for bagasse to produce products such as paper, fiberboard, furfural, etc. In this latter case, the dehydration process results in more bagasse being available for these secondary products.

Several dryer manufacturers now offer bagasse dehydration systems which can reduce the moisture of the bagasse to much lower levels. This report is an economic study based on the fixed costs, operating costs, and capacity of a typical rotary drum dryer using flue gas as the primary and sole source of heat.

Although the process itself is not complex, the savings that can be obtained, and thus the justification of the capital investment is elusive. This paradox is true since the capacity of the dryer varies with the temperature of the flue gases, and the bagasse heat of combustion varies with the initial and final moisture contents of the bagasse. The return on investment for a single system is further based on the total increase in heat of combustion of the bagasse in terms of fuel equivalence and the local price of that fuel.

The purpose of this report will be to show the theoretical interrelationship of these various parameters and how they affect the return on investment for a single dryer system.

DISCUSSION

The return on investment shall be stated in terms of the number of years required to pay back the initial invested capital for the dryer system. In order to obtain this answer, the steps necessary for making this determination are as follows:

A. Dryer capacity versus stack gas temperature
B. Increase in heat of combustion of bagasse in terms of fuel oil equivalence
C. Cost of dryer system
D. Operating costs
E. Return on investment

A. DRYER CAPACITY VERSUS STACK GAS TEMPERATURE

Dryer capacity will vary from manufacturer to manufacturer depending on the type of dryer and efficiency of the system. The data presented in this report is based on a rotary drum dryer 12 feet in diameter by 72 feet long, as illustrated in Figure No. 1.

Figure No. 2 is a graph that indicates the approximate capacity of the dryer with respect to different stack gas temperatures (T_1). The flow rates through the dryer are in terms of bone dry bagasse to eliminate any confusion arising from moisture into versus moisture out of the dryer.

The graph is based on specific design parameters which approximate existing conditions of most sugar mills around the world. The graph is reasonably accurate for bagasse with initial moisture contents varying between 45 percent (wet basis), and 55 percent. The bagasse percent moisture reduction (ΔM) represented by the abscissa is the difference between the dryer input moisture content (wet basis), and the output moisture content. The ordinate then, represents the dryer capacity (T) in bone dry short tons (2000 lbs.) per hour of bagasse flow rate through the dryer. The capacity of the dryer also depends on the temperature of the stack gas at the dryer inlet.

B. INCREASE IN HEAT OF COMBUSTION OF BAGASSE IN TERMS OF FUEL OIL EQUIVALENCE

The first step is to determine the net difference in heat of combustion of the bagasse that can be obtained from the reduction in moisture content (ΔM), and converted into steam by the boiler. To do this, it is necessary to calculate the heat of combustion of the bagasse before and after drying. The general equation for determining the heat of combustion (Q) of bagasse is included in the appendix of this report.

The total amount of heat convertible into steam must allow something for the increase in boiler efficiency as a result of burning lower moisture bagasse. This is assumed to be at least 5 percent for a moisture reduction of 10 percent in the bagasse.

Therefore the net increase in heat of combustion ΔQ (BD), for bagasse on a bone dry basis, is equivalent to:

$$\Delta Q\ (BD) = Q\ (BD)\ (out) - Q\ (BD)\ (in)$$

The fuel oil equivalence (E) for this increase in usable heat of combustion which can be converted into steam by the boiler, and expressed in terms of heavy oil, is then equal to:

$$E = \frac{\Delta Q\ (BD) \times 1.05 \times 2000}{145{,}000}$$

Where E is equivalent gallons of heavy oil per short ton (2000 lbs.) of bone dry bagasse burned, and the oil is considered as having a heat of combustion of 145,000 BTU per gallon.

C. COST OF DRYER SYSTEM

The actual cost of a dryer system will vary significantly with each project, and from one manufacturer to another. However, for this report the total installed capital cost (C) of a single dryer system is estimated to be $450,000.00. This cost is broken down as follows:

a) Dryer System................................ (as shown in Figure No. 1)	$285,000.00
b) Crating and Freight..........................	10,000.00
c) Conveyors and Stack Gas Ducts................. (can vary greatly)	60,000.00
d) Installation.................................	95,000.00
	$450,000.00

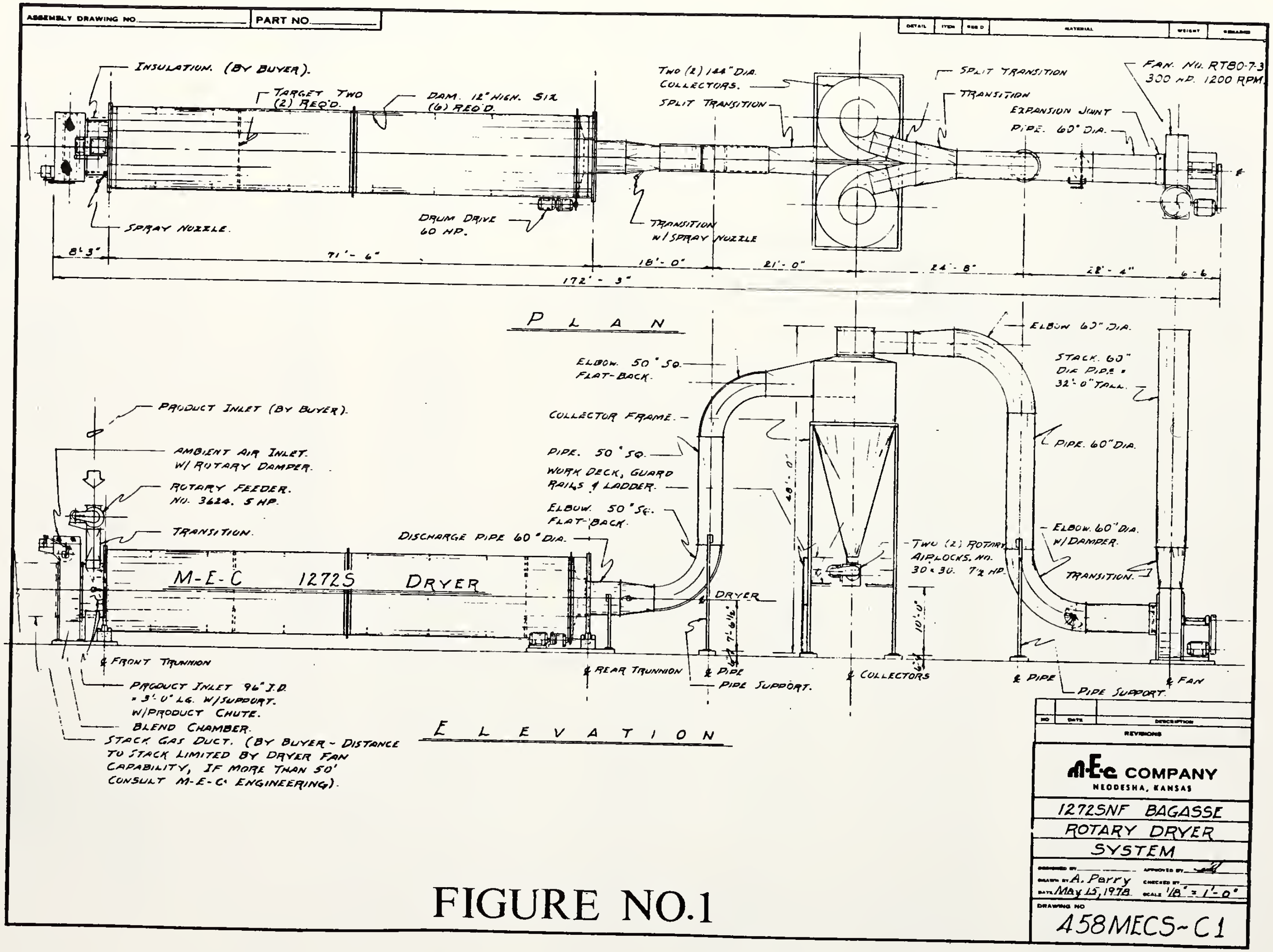

ASSEMBLY DRAWING NO.
PART NO.
INSULATION. (BY BUYER).
TARGET TWO (2) REQ'D.
DAM. 12" HIGH. SIX (6) REQ'D.
TWO (2) 144" DIA. COLLECTORS.
SPLIT TRANSITION
SPLIT TRANSITION
TRANSITION
EXPANSION JOINT
PIPE. 60" DIA.
FAN. NO. RT80-7-3 300 HP. 1200 RPM.
SPRAY NOZZLE.
DRUM DRIVE 60 HP.
TRANSITION W/SPRAY NOZZLE
8'-3"
71'-6"
18'-0"
21'-0"
24'-8"
28'-4"
6'-6
172'-3"
PLAN
ELBOW. 50" SQ. FLAT-BACK.
COLLECTOR FRAME.
PIPE. 50" SQ.
WORK DECK, GUARD RAILS & LADDER.
ELBOW. 50" SQ. FLAT-BACK.
DISCHARGE PIPE 60" DIA.
ELBOW 60" DIA.
STACK. 60" DIA PIPE × 32'-0" TALL.
PIPE. 60" DIA.
ELBOW. 60" DIA. W/DAMPER.
TRANSITION.
TWO (2) ROTARY AIRLOCKS. NO. 30 × 30. 7½ HP.
48'-0"
10'-0"
7'-6½"
PRODUCT INLET (BY BUYER).
AMBIENT AIR INLET. W/ROTARY DAMPER.
ROTARY FEEDER. NO. 3624. 5 HP.
TRANSITION.
M-E-C 1272S DRYER
℄ DRYER
℄ FRONT TRUNNION
℄ REAR TRUNNION
℄ PIPE
PIPE SUPPORT.
℄ COLLECTORS
℄ PIPE
PIPE SUPPORT.
℄ FAN
PRODUCT INLET 96" I.D. × 3'-0" LG. W/SUPPORT. W/PRODUCT CHUTE.
BLEND CHAMBER.
STACK GAS DUCT. (BY BUYER - DISTANCE TO STACK LIMITED BY DRYER FAN CAPABILITY, IF MORE THAN 50' CONSULT M-E-C ENGINEERING).
ELEVATION
DETAIL
ITEM
REQ'D
MATERIAL
WEIGHT
REMARKS
NO
DATE
DESCRIPTION
REVISIONS
M-E-C COMPANY
NEODESHA, KANSAS
1272SNF BAGASSE ROTARY DRYER SYSTEM
DESIGNED BY
APPROVED BY
DRAWN BY A. Parry
CHECKED BY
DATE May 15, 1978
SCALE 1/8" = 1'-0"
DRAWING NO
458MECS-C1

FIGURE NO.1

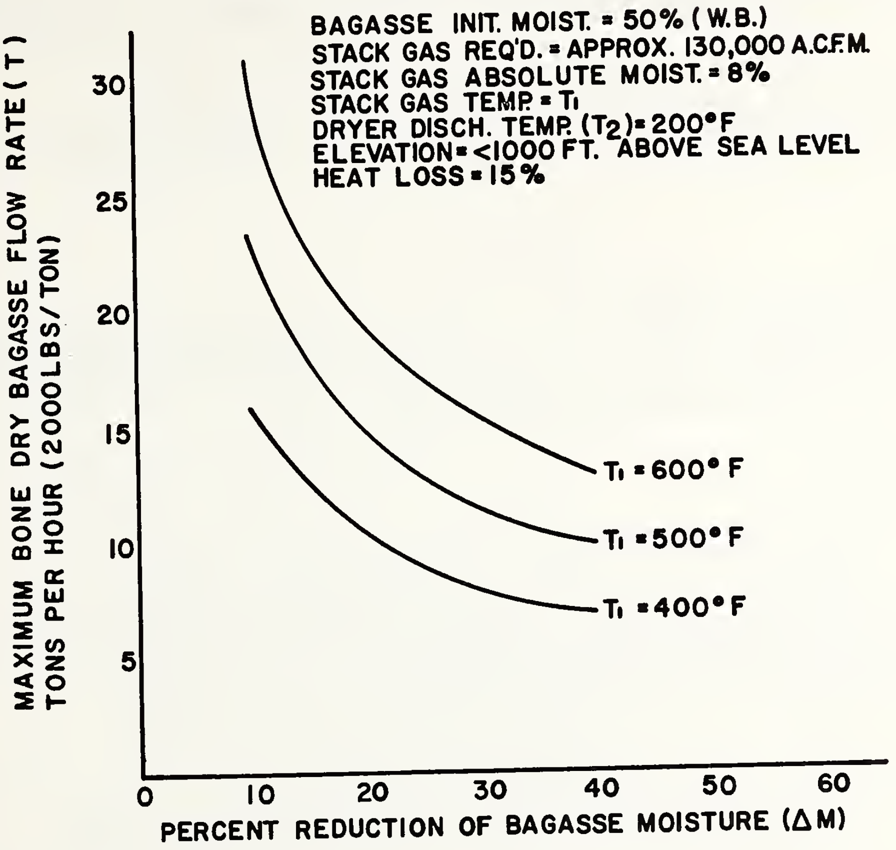


Figure 2. Approximate capacity of one model 1272 SNF bagasse dryer

D. OPERATING COSTS

The operating cost of a single dryer system as illustrated in Figure No. 1 is composed of two principle factors. These factors are as follows:

a) Electrical power

b) Operating and maintenance labor and materials

The cost of electrical power per year (C_p) is based on a total connected load of 420 Horse Power (HP). With a 70 percent service factor, this is equivalent to a continuous load of 220 KWH per hour. (420 HP/HR x .7 service factor x .7457 KWH/HP). Then the cost of power is equal to:

$$C_p = 220 \text{ KWH/HR} \times e \times H$$

Where e = cost per KWH of electricity

H = Hours per year dryer system is in operation

The amount of labor required to operate and maintain a single dryer system is minimal. The estimated values for operator and maintenance labor per year is as follows:

a) Operators = 225 man hours per year
(½ HR/shift x 3 shifts x 150 days/season)
b) Maintenance = 675 man hours per year
(½ HR/shift x 3 shifts x 150 days + 450 hours)
Total = 900 man hours per year

The cost of materials for repair and replacement of parts is assumed to be approximately $15,000 per year.

Then the total cost of operating labor and maintenance costs (C_m) is equal to:

$$C_m = [900 \times r] + \$15,000$$

Where r = Cost of labor per hour including fringe benefits.

E. RETURN ON INVESTMENT

The return on investment (R) for a single dryer system in terms of years required to pay back the initial capital investment involves all of the preceding determinations. The final equation to determinte the pay back years is then:

$$R = \frac{C}{(T \times E \times H \times C_o) - C_p - C_m}$$

Where:
R = Years to pay back investment
C = Capital cost of investment
T = Dryer capacity of bone dry bagasse, tons per hour (2000 lbs/ton)
E = Oil equivalence resulting from bagasse moisture reduction, gallons heavy oil burned per ton of bone dry bagasse burned.
C_o = Cost per gallon of heavy oil
C_p = Total cost of electrical power per year
H = Hours per year dryer system is in operation
C_m = Cost per year of maintenance labor and materials

SAMPLE ANALYSIS OF DRYER PERFORMANCE

The performance of the dryer and the expected return on investment, as previously described is dependent on many factors. However, a sample analysis based on a set of given conditions is helpful to clarify the various relationships between these conditions.

The three matrix charts shown in Figure No. 3 are based on a set of fixed conditions, which approximate actual conditions for the sugar industry in the United States. The only variables allowed to change are the temperature of the stack gas (T_1), and the amount of moisture reduction in the bagasse (ΔM). The fixed conditions used in this analysis are as follows:

Dryer size = As shown in Figure No. 1

Dry capacity (T) = As shown in Figure No. 2

Ash content of bagasse (ASH) = 5 percent

Cost of electrical power (e) = $0.03 per KWH

Hours dryer operates (H) = 3600 hours per year

Cost of labor (r) = $10.00 per man hour

Cost of heavy fuel oil C_o = $0.30 per gallon (USA)

CORRECTION: Page 153, ASSCT Proceedings of 1978 Meeting

	EFFECT ON T (TONS/HR)		
	ΔM=10%	ΔM=20%	ΔM=30%
T_1 = 400° F	16.0	10.5	8.0
T_1 = 500° F	23.5	15.0	11.5
T_1 = 600° F	31.0	19.5	15.5

	EFFECT ON E (GAL/TON)		
	ΔM=10%	ΔM=20%	ΔM=30%
T_1 = 400° F	7.8	13.3	17.5
T_1 = 500° F	8.0	13.7	18.0
T_1 = 600° F	8.2	14.1	18.5

	EFFECT ON R (YEARS)		
	ΔM=10%	ΔM=20%	ΔM=30%
T_1 = 400° F	5.2	4.4	4.3
T_1 = 500° F	2.9	2.6	2.5
T_1 = 600° F	2.0	1.8	1.7

Figure 3. Sample analysis of the effect varying stack gas temperature (T_1) and moisture reduction (ΔM) has on dryer capacity (T), fuel oil equivalence (E), and return on investment (R).

CONCLUSIONS

The information presented in this report, and the sample analysis support numerous conclusions. These conclusions are as follows:

1. The text of this report describes a systematic method for analyzing the economic justification of a rotary dryer system for dehydrating bagasse using boiler stack gas as the sole source of heat.
2. The sample analysis supports the following:
    a. Depending on the amount of bagasse available and the local cost of fuel, power, and labor, a bagasse dehydrator may be a justifiable investment for stack gases in excess of 400 degrees F.
    b. The greatest return on investment is obtained by drying less bagasse to lower moisture contents. For instance, bagasse dehydrated to 20% can be mixed with 50% bagasse and burned in the boilers. The blended mix will produce a greater return on investment than drying all of the bagasse to some intermediate moisture between 20% and 50%.
3. The sample analysis indicates clearly that the higher the stack gas temperature, the greater the return on investment for the dryer system. This same observation suggests that a by-pass duct around existing air preheaters to increase the temperature of the stack gas fed into the dryer may produce greater fuel efficiency than the preheater.

Figure 3. Sample analysis of the effect varying stack gas temperature (T_1) and moisture reduction (ΔM) has on dryer capacity (T), fuel oil equivalence (E), and return on investment (R).

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APPENDIX

GENERAL EQUATION FOR DETERMINATION OF BAGASSE HEAT OF COMBUSTION

The following derivation if used for the determination of the heat of combustion of bagasse as burned in the boiler at varying moisture and ash contents.

Let:

Heat of combustion of bone dry bagasse = 8350 BTU/lb
M.C. = Moisture content of bagasse
Ash = Ash and non-combustible content
Qi = Total heat of combustion of bagasse as burned
Qm = Heat of combustion required to evaporate bagasse moisture during combustion in boiler
Q = Net heat of combustion available for steam production in boiler.

The net heat available (Q) is then equivalent to the total heat of combustion (Qi) less losses Qm:

$$Q = Qi - Qm$$

Then $Qi = 8350\ \text{BTU/lb}\ (1 - \text{M.C.} - \text{Ash})$

Then $Qm = \text{M.C.} \times \Delta H$

ΔH = Change in enthalpy of saturated water liquid at T_{pl} and superheated water vapor at T_1 temperature.

T_{pl} = Temperature of moisture in bagasse being fed into boiler

T_1 = Temperature of combustion gases and water vapor discharged from boiler air preheater

$$Qm = \text{M.C.}\ (H_1 - H_{pl})$$

Common values of enthalpy for saturated liquid water are as follows:

T_{pl}	H_{pl} = Values of enthalpy for saturated liquid BTU/lb
60°F	28
80°F	48
100°F	68

Common values of enthalpy for superheated water vapor at pressures assumed near atmospheric conditions are as follows:

T_1	H_1 = Values of enthalpy for water vapor BTU/lb
300°F	1193
400°F	1240
500°F	1287
600°F	1335
700°F	1384
800°F	1433

Then $Q = Qi - Qm$

$$Q = [8350 \times (1.0 - \text{M.C.} - \text{Ash})] - \text{M.C.}\ (H_1 - H_{pl})$$

Therefore, the net heat of combustion for bagasse of varying moisture and ash content, and based on the as burned (AB) weight of the bagasse is then:

$$Q\ (AB) = 8350\ (1.0 - M.C. - Ash) - M.C.\ (H_1 - H_{pl})$$

The net heat of combustion for bagasse of varying moisture and ash content, and based on the bone dry (BD) weight of the bagasse is then:

$$Q\ (BD) = \frac{[8350\ (1.0 - M.C. - Ash)] - M.C.\ (H_1 - H_{pl})}{1.0 - M.C.}$$

Where: M.C. = Moisture content of bagasse being burned, Percent ÷ 100.

Ash = Ash and non-combustibles, percent ÷ 100.

H_{pl} = Enthalpy of saturated liquid water at temperature T_{pl}

H_1 = Enthalpy of superheated water vapor at temperature T_1.

BIOMASS AND SUCROSE PRODUCTION IN SUGAR CANE:
I. DIVERGENT SELECTION STRATEGIES

R. D. Breaux and B. L. Legendre
U. S. Sugar Cane Field Laboratory, USDA
Science and Education Administration
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

The yield components desirable in a sugar cane variety to be used for biomass production differ from those in a variety for sugar production; total solids (fiber + Brix) percent cane and total solids per hectare replace sugar per tonne and sugar per hectare. All these yield components were measured in 30 clones each of an F_1, BC_1, BC_2 and two BC_3 progenies of S. spontaneum US 56-158 bred to commercial-type sugar canes.

The highest mean yield of total solids per hectare occurred in the F_1 progeny, but the highest mean yield of sugar per hectare occurred in the BC_3 progenies. Backcrossing to commercial varieties resulted in a sharp reduction in yield of tonnes of cane per hectare in the BC_1 progeny and a more gradual reduction in total solids percent cane. The yield of sugar per hectare increased with the backcross generation, because the increase in sugar per tonne of cane more than compensated for the loss of cane tonnage. The data show that, if selection pressure for sugar per tonne of cane were removed, it would be possible to select varieties that yield much more biomass than varieties grown commercially for sugar production.

OVERWINTERING SUGAR CANE BORER POPULATIONS IN TEXAS, 1977-1978

T. W. Fuchs
Texas Agricultural Experiment Station
Weslaco, Texas

Populations of the sugar cane borer, Diatraea saccharalis, were unusually high in the Rio Grande Valley of Texas during 1977. This was presumably due to the carryover of approximately 8,000 acres of unharvested sugar cane from the previous season, plus the reduced amounts of insecticide used by producers on the low-priced sugar cane. Ten harvested sugar cane fields chosen at random were sampled to estimate the number of overwintering sugar cane borer larvae remaining in fields after the 1977-78 harvest. The data indicated an average of 356 larvae per acre. One-third (33.3 percent) of the larvae were found in stubbles and two-thirds (66.7 percent) in trash left by harvesters. Data from studies designed to determine the percent mortality of sugar cane borers overwintering in cane stubbles indicated that no significant mortality occurred during the winter of 1977-1978.

POTENTIAL CYTOGENETIC APPROACH IN SUGAR CANE BREEDING

Bikram S. Gill
University of Florida
Agricultural Research and Education Center
Belle Glade, Florida

Two concepts have recently emerged from the cytogenetic analysis of genome in polyploid plant species. First, the diploid-like chromosome pairing in a polyploid is controlled by a single major gene. In the absence of this gene, multivalent formation occurs during metaphase I of meiosis. Secondly, in hybrids involving a polyploid plant (which is missing the chromosome pairing gene) with related genera, intergenomic chromosome pairing also occurs. In wheat, a mutation (possibly a deletion) of the chromosome-pairing gene has been used to transfer genes from genera as far removed as Agropyron and rye. There is an urgent need for basic cytogenetic research in sugar cane to elucidate the genetic control of chromosome pairing and explicate its use in intergeneric gene transfers. Some other recent advances in chromosome cytology also need to be explored for possible application in sugar cane breeding.

SCREENING FOR RESISTANCE TO RATOON STUNTING DISEASE-INJURY; THE ENZYME-LINKED IMMUNOSORBENT ASSAY

A. G. Gillaspie, Jr., and R. W. Harris
USDA, Science and Education Administration
Beltsville, Agricultural Research Center
Beltsville, Maryland

The microplate method of enzyme-linked immunosorbent assay (ELISA) will differentiate in greenhouse and laboratory tests, between clones that are susceptible or resistant to ratoon stunting disease (RSD) injury. The ELISA method could be useful for a large-scale screening program if it works as well in field tests as it does in the laboratory tests. Wells of a polystyrene microplate are coated with a gamma globulin preparation containing antibodies to the RSD-associated bacterium. Juice samples are then placed in the wells and are incubated for three hours at 37° C. During incubation, the RSD bacteria become attached to the well surface. After the wells are washed, the anti-RSD gamma globulin, coupled with an enzyme, such as alkaline phosphatase is placed in the wells, the plates are incubated at room temperature for one hour at 37° C. so that the enzyme-antibody complex attaches to the bacteria. Following a thorough rinse with physiological saline containing 0.1 percent Tween 20, the substrate for the enzyme is placed in the wells, the plates are incubated at room temperature for one hour, and the color formation is stopped with 3M sodium hydroxide. The intensity of the color development in the ELISA test is directly related to the number of bacteria present in a sample. Susceptible clones have been reported to contain a higher number of diagnostic bacteria than resistant clones and this makes possible the use of ELISA as a screening technique. The ELISA test will detect the RSD-associated bacterium down to a concentration of about 4×10^6 bacteria per milliliter or about 3 bacteria/phase contrast microscope field.

CLOSE ROW-SPACING AND SUGAR CANE YIELD

J. E. Irvine and R. J. Matherne
U. S. Sugar Cane Field Laboratory, USDA
Science and Education Administration
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

Field plots with inter-row spacings of 61 centimeters, 91 centimeters and 183 centimeters with a single drill, and 183 centimeters with a double drill were sub-plots of a split-plot design; the main effects varied in the manner of N fertilizer application, either as a solid or in aqueous solution. The sugar cane variety CP 65-357 was planted in the fall of 1976 on level land at Houma, Louisiana. Monthly observations began in May, 1977, and included population counts, height measurements, leaf determinations, yield estimations and determinations of tissue nutrient levels. No significant differences were observed in response to spacing, and these included differences in plant population, leaf area index, yield of biomass, and net cane and sugar per hectare.

Stalk populations were highest in June and declined until harvest in December; June populations for the 61-centimeter spacing peaked at 180,000 stalks per hectare, compared to 92,000 for the standard 183-centimeter spacing. Leaf area reached a maximum in September, when the ratio of leaf to land area for the 61-centimeter and the 183-centimeter single-drill spacings were 5.66 and 2.76, respectively. Yields increased steadily until the mid-December harvest, when sugar yields for 61-centimeter, 91-centimeter and 183-centimeter double-drill, and 183-centimeter single-drill spacings averaged 18.0, 13.3, 11.9 and 10.9 tonnes per hectare, respectively.

NARROW-ROW SPACING OF SWEET SORGHUM IN OHIO

W. T. Lawhon and Stephen Kresovich
Battelle-Columbus Laboratories, Columbus, Ohio

Since the mid-19th Century, the sweet sorghums have periodically attracted the interest of farmers and sugar producers in the United States because of the sucrose content in their stalks. Preliminary results now indicate that sweet sorghums may show a great potential for a source of energy, particularly in the Midwest U. S.

A demonstration was performed at Columbus, Ohio, in the summer of 1977, the general results of which indicate that sweet sorghum can be grown in the Midwest with yields comparable to the rest of the sweet sorghum production regions. At the 0.5-meter row spacing, the Sart variety yielded 25.6 dry tonnes per hectare, Ramada yielded 18.1 dry tonnes per hectare, Rio yielded 15.4 dry tonnes per hectare and MN 1200 yielded 9.4 dry tonnes per hectare, based on projections from "wheel"-type planting arrangements.

The juice qualities of these varieties were low, because the planting operations were late and the crop never completely matured. However, two variables, the narrow-row spacing and early maturing varieties of sweet sorghum, offer a possibility for an energy crop for the Midwest U. S.

BIOMASS AND SUCROSE PRODUCTION IN SUGAR CANE:
II. ASSOCIATION WITH YIELD COMPONENTS

B. L. Legendre and R. D. Breaux
U. S. Sugar Cane Field Laboratory, USDA
Science and Education Administration
Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

The relationship between yield components and biomass and sucrose production were studied in 30 clones of an F_1, BC_1, BC_2 and two BC_3 progenies of S. spontaneum US 56-158 bred to commercial types of sugar cane. Both total solids (a biomass component) and sugar per hectare were highly associated with tonnes of cane per hectare for all progeny generations. Sugar per hectare was positively associated with sugar per tonne of cane. Total solids were negatively associated with sugar per tonne when all generations were combined; however, there was no association of total solids with sugar per tonne of cane within generations. Total solids were associated with fiber percent cane, but, within a progeny generation, sugar per hectare was not. In all generations, total solids were associated with sugar per hectare and both were associated with tonnes of cane per hectare. Despite these associations, the opposite effects that selection for sugar per tonne of cane has on biomass and sugar production require separate breeding programs.

FUELS FROM SUGAR CROPS: STATUS AND PROSPECTS

E. S. Lipinsky
Battelle-Columbus Laboratories
Columbus, Ohio

The development of liquid transportation fuels from sugar crop biomass at costs that are attractive in the marketplace is a formidable task. An integrated Department of Energy program which started in 1975 is making progress in reducing raw material costs through narrow-row spacing of sugar cane and sweet sorghum, the use of Tilby cane separator, new methods of cellulose hydrolysis and improvements in fermentation processes. This paper presents an overview of new agricultural and processing technologies that relate to liquid fuel production. Potential impacts on sugar crop growers, processors and fuel consumers are discussed.

BREEDING FOR AND SELECTING SUGAR CANE GENOTYPES THAT RESPOND TO "RIPENERS"

F. A. Martin
Louisiana Agricultural Experiment Station
Louisiana State Uiversity
Baton Rouge, Louisiana

For two consecutive years, 24 experimental sugar cane varieties were tested for response to the chemical ripener glyphosine. Six weeks after treatment, the effects of glyphosine on stalk weight, sugar per tonne and sugar per acre were determined. The genotypic variation of response was observed for the three yield components. Of particular interest was the range of the effect on stalk weight (from positive to negative) that was apparently associated with genotypic variation. The fact that crosses which yield high frequencies of positively responding progeny can be identified should make breeding and selection for response to chemical ripeners feasible.

THE POTENTIAL OF THE SACCHARUM COMPLEX FOR THE PRODUCTION OF FIBER

F. A. Martin and M. J. Giamalva
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

The possibility of using plants within the Saccharum complex for the production of fiber is explored. It is proposed that production of 100 tonnes of 35 percent fiber cane is technologically attainable. Production of this wilder-type cane may be less complicated than the production of domestic sugar cane. The monthly variations in available yield in relation to possible uses is also discussed.

RELATION OF POLLEN AND PISTIL CHARACTERISTICS IN SETTING OF TRUE SEED IN SUGAR CANE CROSSES

S. Nagatomi
Tanegashima Branch, Kyushu Agricultural Experiment Station
M.A.F. Nishinoomote, Kagoshima, Japan, and
P. H. Dunckelman
U. S. Sugar Cane Field Laboratory, USDA
Science and Education Administration, Houma, Louisiana
(In cooperation with the Louisiana Agricultural Experiment Station)

A study of the association between seed set in sugar cane crosses and the condition of the floral organs was made in Houma, Louisiana. A positive correlation was found between breeding generations and the size and variability of pollen grains. The more highly nobilized the generation, the larger and more variable were the pollen grains. Seed set increased exponentially with pollen maturity and was closely associated with anther dehiscense and shedding of pollen in the male parent. Better seed set can be expected in interspecific crosses when 60 percent or more of the pollen grains of male parents are mature, and the stigmas of the female parents are fully extended beyond the glumes. Seed set in intergeneric crosses was apparently influenced by sexual incompatibility rather than by pollen maturity or stigma extension. Specific techniques for making intergeneric crosses are suggested.

WINTER AND SPRING PHOTOPERIODIC INDUCTION FOR SYNCRONIZING FLOWERING IN SUGAR CANE

Elias D. Paliatseas
Department of Plant Pathology
Louisiana Agricultural Experiment Station
Louisiana State University
Baton Rouge, Louisiana

Thirty-two varieties of sugar cane were grown in the greenhouse in the fall of 1977. Two to ten stalks from each of these, depending on the availability of mature shoots were marcotted from October 15, 1977, through January 15, 1978. When the roots had developed, the stalks were cut and transplanted into 10-gallon galvanized cans filled with a mixture of soil, peat moss and sand (3:2:1). Then, the 32 varieties were divided in three groups. The first group consisted of 10 varieties which were transferred into the plastic greenhouse and placed under inductive photoperiod treatment on November 20, 1977. The second group of 10 varieties was placed under photoperiod treatment on January 10, 1978. The third group was placed under photoperiod treatments on February 10, 1978. The length of the inductive photoperiod treatments given to the three groups of varieties through April 8, 1978, was 139, 88 and 57 days, respectively. From April 9 through mid-summer 1978, the three groups of varieties will be given the same inductive photoperiod treatment.

Signs of flowering were visible on March 30, 1978, in five varieties belonging to the first group. These varieties will probably flower in June, 1978. Other varieties from the first group and from the second and third group will probably flower in the middle and late summer. This will enable the crossing of these varieties with some early and mid-summer flowering cold-resistant Saccharum spontaneum L. clones, especially US 60-46 and US 61-21. This will probably result in the transmission of some cold resistance into the commercial sugar cane varieties.

KNOWN DISTRIBUTION OF THE IMPORTED FIRE ANT *SOLENPSIS INVICTIA* BUREN IN FLORIDA SUGAR CANE FIELDS: BENEFIT OR PROBLEM FOR THE FUTURE

Jerry Prewitt
United States Sugar Corporation, Clewiston, Florida
Ralph Brown
Florida Department of Agriculture
Division of Plant Industry, Gainesville, Florida
T. L. Carpenter
South Bay Growers, Inc., South Bay, Florida
G. B. Powell
Gulf + Western Food Products Co., South Bay, Florida, and
T. E. Summers
USDA, Science and Education Administration
Canal Point, Florida

Solenopsis invicta Buren was found to have penetrated the interior of sugar cane fields during 1977. Mounds along edges of fields had been observed in 1976, but were not reported. The limits of observed infestations and the possible benefits of the fire ants as predators of the sugar cane borer and their effect as destructors of beneficial insect populations in sugar cane fields are discussed. The problems encountered by field personnel are reported.

NARROW ROW SPACINGS OF SWEET SORGHUM IN TEXAS

Sim A. Reeves, Jr.
Texas Agricultural Experiment Station
Weslaco, Texas
B. A. Smith
USDA, Science and Education Administration
Food Crops Laboratory
Weslaco, Texas
and B. W. Hipp
Texas Agricultural Experiment Station
Dallas, Texas

Among crop plants of adaptation in the Lower Rio Grande Valley of Texas, sweet sorghum is a possible source of biomass with feasibility for fermentation into ethyl alcohol, a primary, alternate source of energy. The sucrose variety Rio and the syrup variety Sart were selected for this study and planted into 40 and 27-inch rows. Due to insect damage, Sart was discarded in the middle of the season and the strain MN 1500 which was growing on 27-inch rows, was substituted. The Rio variety grown on 27-inch rows produced 52 percent more dry biomass than Rio grown on 40-inch rows. The total dry weight production of MN 1500, with a yield of 17.53 tonnes, was superior to Rio, with 8.69 tonnes per acre. The total sugars produced were higher in MN 1500, compared to Rio, and MN 1500 produced the greatest amount of dry fiber, with 8.90 tonnes, compared to 3.72 tonnes per acre for Rio.

METHODS OF PLANTING SUGAR CANE IN LOUISIANA

R. Ricaud, B. J. Cochran and G. W. Newton
Agronomy and Agricultural Engineering Departments
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

An experiment was conducted to determine the effects of type and width of planting furrows on the growth characteristics, yield and harvestability of sugar cane. The types of furrows were single and multiple drills on standard rows six feet wide. The multiple drills were planted with one line of seed cane in each drill spaced 12 inches apart. The total widths of the single and multiple drills were 12, 24, 36 and 48 inches. For each width, the same amount of seed was planted in both types of furrow. A standard V-furrow with one drill was used as a check. The plant population with each method of planting increased to a maximum in July and decreased thereafter until October. At harvest time the 36-inch width produced the highest stalk population, and plant height increased with increasing widths of planting. Stalk diameter was smaller with the V-furrow and 24-inch width than with the wider plantings. The methods of planting did not affect percent sucrose. The 36-inch width of planting produced the highest total biomass yield and sugar yield per hectare. The single and multiple drills produced similar results for each width of planting.

DETERMINATION OF NITRATE AND AMMONIUM LOSSES BY LIXIVIATION IN A CULTIVATED SUGAR CANE FIELD

S. Saldarriaga A., E. Paz-Vergara P. and E. Angulo A.
Instituto Central de Investigaciones Azucareras
Casa Grande, Trujillo, Peru

An experiment was carried out in Cartavio, Chiclin No. 10 field, in a soil varying from medium to moderately fine texture, located on the northern arid coast of Peru, which was planted with sugar cane cultivar H 32-8560, fertilized with 240 kilograms of N per hectare and harvested at 21.1 months of age. It was installed with the purpose of determining the nitrate (NO_3-N) and ammonium (NH_4^+-N) quantities that are lost in the drainage water. After evaluating the results, it is found that there are greater nitrate losses than losses of ammonium. Moreover, a method to determine the losses of these ions is presented. According to this method, it has been calculated that, within the base flow of drainage, there is a loss almost constant of 13.5 kilograms of N per hectare per year, while losses arising from applied nitrogen fertilization due to lixiviation by irrigation are 8.1 kilograms of N per hectare per year, which results in a total loss of 21.6 kilograms of N per hectare per year.

INFLUENCE OF NITROGEN APPLICATION METHODS AND UREA SOURCES ON THE RESPONSE OF TWO SUGAR CANE CULTIVARS

S. Saldarriaga A. and M. Feijoō A.
Instituto Central de Investigaciones Azucareras
Casa Grande, Trujillo, Peru

An experiment was conducted in a calcareous alluvial soil, located at Tuman Sugar Plantation, Chancay River Valley, on the arid northern coast of Peru. It was installed with the purpose of studying the influence of three N application methods and two urea sources on the response of two sugar cane cultivars. After evaluating the results, it is found that the top dressing application on dry soil with immediate irrigation and the buried application significantly exceed in cane yields (tonnes per hectare) and recoverable sugar (tonnes per hectare) the top dressing on moist soil application. Moreover, it is found that sugar cane cultivar H 50-7209 significantly exceed in cane and sugar yields the cultivar Lar 52-604. No significant differences were found between the national and European ureas.

WEED CONTROL SYSTEMS IN TEXAS SUGAR CANE

Andrew W. Scott, Jr.
Rio Farms, Inc., Monte Alto, Texas and
Sim A. Reeves, Jr.
Texas A & M Experiment Station
Weslaco, Texas

During the five years of sugar cane production in the Rio Grande Valley of Texas several weed-control systems have been developed for both plant and ratoon sugar cane. Planting is accomplished, with few exceptions, from mid-August to early November, and the majority of all plant cane receives a herbicide application at planting. This application is applied broadcast or band pre-emergence or band post-emergence. Plant cane is then usually treated with a lay-by herbicide in the spring. Sugar cane in the Rio Grande Valley of Texas is harvested from mid-October to mid-April. Weed-control systems for ratoon cane have been developed to fit the time of harvest and weed pressure. A field harvested early during the season may require two herbicide applications, whereas a field harvested late in the season will probably require only one herbicide application. Weed-control systems for ratoon cane which make limited use of herbicides have also been developed.

WATER QUALITY STUDIES IN THE EVERGLADES AGRICULTURAL AREA

Earl E. Shannon
Black, Crow & Eidness/CH_2 M Hill, Gainesville, Florida, and
Fred E. Davis
South Florida Water Management District
West Palm Beach, Florida

Water quality and agricultural practices were monitored for the period of July, 1976, to September, 1977, at three large farming operations (sugar cane, vegetable and improved pasture) in the Everglades Agricultural Area of Florida. Significant sources and sinks of nitrogen, phosphorus and water for each site were measured and quantified. The nutrient sources evaluated included bulk precipitation, fertilization, soil mineralization and nitrification, and irrigation. The nutrient sinks considered were drainage water discharge, crop export and denitrification. Water losses due to evapotranspiration and drainage, along with water inputs from precipitation and irrigation were continuously monitored. Nitrogen and phosphorus balances for each operation are presented. Nitrogen and phosphorus loadings are compared to previously reported loadings for agricultural operations on organic soils.

PRODUCING HIGH-QUALITY CANE FROM THE CHOPPER (OR COMBINE) TYPE HARVESTER

Frank Smith
Toft Bros. Industries, Ltd., Bundaberg, Queensland, Australia

Although chopper-type harvesting is not new, its introduction in many areas of the world is relatively recent, as in Louisiana and Florida. In most cases, the introduction of chopper-type harvesting leads to the establishment of a new set of standards in most aspects of cane sugar production, from planting through cultivation, harvesting and milling. The chopper-type harvesting is usually introduced to offset a number of undesirable trends that have become very much a part of the industry over the past decades. Not the least of these problems is, of course, the increasing unavailability of sufficient manual labor to harvest the cane. Coupled with this is the need to maintain control of rising costs, a factor of prime importance in the last two or three years, when world sugar prices have been so low.

The paper will concentrate on the production of high-quality chopped cane from a typical chopper-harvester system. The discussion is meant to create an awareness of the requirement of supplying clean, sound cane to the sugar mill. It also covers in some detail the various functions of the systems involved in the harvesting and loading of cane, and the influence these practices have on the quality of cane delivered to the mill.

FIELD EVALUATION OF INSECTICIDES FOR CONTROL OF THE WHITE GRUB BOTHYNUS SUBTROPICUS IN FLORIDA SUGAR CANE

T. E. Summers and M. G. Bell
USDA, Science and Education Administration
Canal Point, Florida, and
Jerry Prewitt, D. G. Holder and J. D. Stacy
United States Sugar Corporation, Clewiston, Florida

Topical tests for acute toxicity to second and third-stage larvae of *Bothynus subtropicus* Blach. showed several insecticides, including carbofuran, ethoprop and fonofos, to be effective when applied in this manner. Twenty-one common insecticides were subsequently included in field tests using one or more of the following methods of application: applied at planting time in the conventional method used for wireworm control; applied over the stubble as a drench, following harvest; metered into water being pumped into stubble plots; injected into a split opening made in the center of the stubble row by mechanical coulter; and applied to the base of growing plants at or near time of emerging female adults, with a thin layer of soil thrown over the material by a rolling tillivator. The last method, using light traps or attractant boards to determine the proper time of application, appears to be the most promising method of successfully using the short-lasting insecticides available in a total program which also involves cultural and biological control methods for the control of this and allied soil pests in the highly organic soils of Florida sugar cane fields.

HIGH-PRESSURE LIQUIDE CHROMATOGRAPHY (HLPC) AND THE ANALYSIS OF SUGARS

Luis E. Vidaurreta
Department of Chemistry
Louisiana State University, Baton Rouge, Louisiana

This presentation covers the research done to date in the practical analysis of fructose, glucose and sucrose in sugar cane juice at the Chemistry Department and the Audubon Sugar Institute at Louisiana State University.

EFFECTS OF SUGAR CANE MOSAIC VIRUS ON SUGAR CANE IN SOUTH TEXAS

Ben Villalon
Texas Agricultural Experiment Station
Weslaco, Texas

The effects of sugar cane mosaic virus (SCMV) strain H on plant growth rate, height, barrel diameter and yields of plant and first-stubble crops of the commercial varieties NCo 310, CP 61-37, CP 65-357 and CP 52-68 were compared in replicated field test. Highly significant differences were found between healthy and mosaic-infected plants on all varieties with respect to plant height, stem diameter, total weight, strip weight and factory calculated yields. Average yield reductions for all varieties was 5.74 percent in plant cane and 11.27 percent in first-ratoon crops.

ANALYSIS OF SUGAR CANE SACCHARIDES BY LIQUID CHROMATOGRAPHY

J. Wong-Chong and F. A. Martin
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

The application of High-Pressure Liquid Chromatography in the fractionation of sugar cane saccharides using cation-exchange resins is described. Resolution of sucrose, glucose and fructose in cane juice samples can be completed in less than eight minutes. and the products of juice deterioration can also be detected with this procedure. Elution is carried out with water as the only solvent and detection of the sugars with a differential refractometer gives good reproducibility of the results.

Muddy samples need only be clarified by centrifugation and deionized in a very simple procedure before injection into the liquid chromatography equipment. Samples containing as much as 15 percent mud have been successfully analyzed by this procedure without adverse effects on the column-packing material.

TILBY JUICE EXTRACTION SYSTEM

Theodore A. Anderson
Andercane, Inc., Pahokee, Florida

The objectives of the Tilby system for separating cane and sweet sorghum are obtaining uncrushed fiber, clean pith (which contains upwards of 90 percent of the juice in cane and sorghum), and the epidermis of the cane, which contains wax. In this system, the separator equipment cuts the stalks in half longitudinally, scrapes out the pith, and scrapes the epidermis from the rind. Through a diffusion process, the sugar juice is extracted from the pith and sugar is washed out of the fiber. Thus, the system provides relatively pure uncontaminated sugar juice, plus clean desugared pith and fiber, at a low cost.

The development of the separator technology got underway in Canada, in 1963. Most of the testing of the equipment for detrashing cane, as required for the separation system, and of the separator equipment itself took place in the West Indies in the late 1960's and early 1970's. More recent testing of the equipment has been conducted in Pahokee, Florida. The unit in use (the C-10 Model) can process 15 tons per hour of detrashed cane. Current developmental efforts are focusing on the detrashing system, which is essential to the efficiency of the separator equipment.

Tests of the components of separated cane are also receiving important attention. The pith has been fed to cattle with good results and it also has been ensilaged for future cattle feed. Juice has been extracted from the pith and tested in the laboratories of sugar mills. The cane fiber has been tested by paper companies and made into four-foot by eight-foot panels, 0.5-inch thick, to compete with plywood.

Future testing will be conducted on sweet sorghum, various species of sugar cane and unburned cane. Also, tests will be made of new equipment for diffusing the sugar juice from the pith. New presses for processing the fiber into boards which will compete in the hardwood market will be tested. Tests are being made to evaluate the economics of the wax component. No factors have appeared so far to slow down the longer-term promise of this new technology.

THE PRESENCE OF AMMONIA AND COPPER IN CONDENSATES AND BOILER FEEDWATER IN FLORIDA SUGAR MILLS

Pedro R. Arellano and James S. Rauh
Olin Water Services, Miami, Florida

Determinations of ammonia and copper were made on samples collected at several Florida sugar mills during the 1977-1978 crop. High levels of non-condensable gases and ammonia in evaporators, juice heaters and vacuum pans reduced their heat-transfer efficiency, caused corrosion of the copper tubing, and contaminated condensates and boiler feedwater with copper. The authors suggest increasing venting of the process equipment to reduce concentrations of non-condensable gases and ammonia to maximize heat-transfer efficiency. Lower ammonia levels will reduce corrosion of copper tubing. With less pitting of the tube surfaces, the tendency for deposits to adhere to the tubes is reduced and this may retard the rate of heat-transfer loss in such equipment. In addition, the resulting lower levels of copper in condensate used for boiler feedwater will reduce potential problems associated with copper in boiler water.

THE LOTUS ROLL - A NEW CONCEPT FOR THE MILLING OF SUGAR CANE

Jean Bouvet
Wen Hsing Machinery & Electronic Industry Corp.
Kaohsiung, Taiwan

Formerly, it was impossible to provide an egress for the pool of sugar cane juice lying on top of the cane blanket entering a mill. This juice was made to recirculate within the blanket, which limited the grinding rate of a mill. A new type of top roll, the perforated "Lotus Roll," is now available to perform that function. The juice expressed by milling enters the Lotus Roll through a number of peripheral perforations and is discharged at both ends of the roll. A higher grinding rate and a higher extraction are expected from the use of the Lotus Roll. The paper discusses the mechanics of milling, the limitations imposed on milling by conventional rolls and the benefits to be derived from the Lotus Roll concept.

THE TYPHOON MASSECUITE FILTER - A NEW CONCEPT IN THE PROCESSING OF MASSECUITE

Jean Bouvet
Wen Hsing Machinery & Electronic Industry Corp.
Kaohsiung, Taiwan

There is now an alternative to the traditional practice of curing massecuites by centrifugal force. The new method uses the principle of vacuum filtration. The system is continuous, simple and requires little maintenance.

A BRIEF ANALYSIS OF HOW THE FACTORY HANDLED THE CANE FROM THE TOTALLY MECHANIZED CUTTING OPERATIONS AT TALISMAN

Tirso M. Carreja
Talisman Sugar Cooperative
Belle Glade, Florida

According to the experience at Talisman, the increase in tops as a result of the mechanized cutting of the cane, as compared with cane cut manually, did not turn out to be as major a problem as expected. The main problem encountered was with the soil that came with the cane cut by the mechanical harvesters. This soil affects, directly or indirectly, various sections of the factory thus creating many problems. After many experiments, the solution to these problems was found in washing the cane before it is ground.

THE DETERMINATION OF ASH IN BAGASSE

James C.P. Chen
Southdown Sugars, Inc.
Houma, Louisiana

The determination of ash in bagasse constitutes a problem similar to that of the determination of Pol or fiber in the cane. The main difficulty is not in the method of analysis, but rather in the collection of sample and the proper way of subsampling so that the results of analysis can be reproduced. After a series of comparisons in parallel between two independent laboratories, using exactly the same procedure, and carried out by two conscientious chemists, a method has finally been developed with excellent reproducibility. The difference between two laboratories can be consistently within 0.5 percent.

DESIGN OF LONG-TUBE JUICE HEATERS

Juan Prieto
Miguel Chinchilla Varona & Associates, Inc.
Vero Beach, Florida

When expanding the capacity of a sugar factory, space considerations have to be taken into account and it has been found that, by using long tubes, juice heaters can be made to take up approximately the same floor area and still achieve the necessary increase in heating surface. Other considerations taken in the design of these heaters are: pressure drop on the tube side; tube length; mechanical specifications; and the periodic cleaning to remove scale. The results of the operations of seven units in two different factories have been good.

THE WASH TABLE IN THE LOUISIANA CANE FACTORY

P. F. Triviz
J&L/Honiron Engineering Company, Inc.
Jeanerette, Louisiana

Although there is no one precise or fixed standard for the feed and wash table which is being used more and more in Louisiana, there is an agreement that its use in the processing of cane that is harvested and loaded mechanically, as is the current practice in Louisiana, increases the overall efficiency to more than offset its cost and maintenance.

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PRESIDENT'S MESSAGE: FLORIDA DIVISION

Joseph R. Orsenigo
Director of Research
Florida Sugar Cane League, Inc.
Clewiston, Florida

During a visit to my alma mater in the summer of 1963, I was incredulous, if not shocked, when a former professor stated that "agriculture is becoming a dirty word." He forecast a buffeting from all sides in future years. I departed the campus positive that the respected professor was senile. But, his generalized prediction became a truism and we, in agriculture, are experiencing a disquieting change. Toffler's "Future Shock" was scant preparation for our collisions with today and with tomorrow. Present shock is the threat to sugar industry survival by our own government.

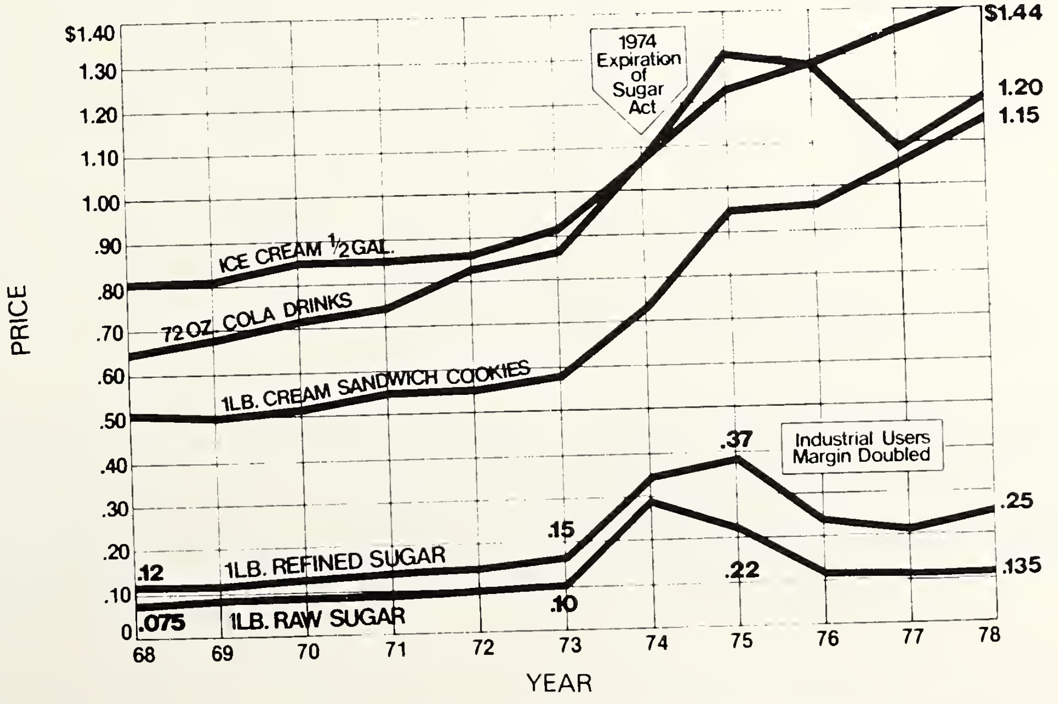
Not surprisingly, this message relates to the current malaise of the domestic sugar industry, and of sugar cane, specifically, in four areas: Politics, Prices, Population, and Production.

Politics and Prices have been the "Bobsey Twins" of the sugar world for many decades and they must be considered inseparable. Sugar crop growers and primary processors are preoccupied with "prices" at present, since price determines "survival" for a long-standing and productive domestic industry. However, prices are mediated by "politics," a strange segment of the domestic sugar picture. The cast of political players is large and the flux is great; it indicates: growers of beets and includes cane, processors, refiners, importers, commercial users, state and federal legislatures, state and federal departments, and the administration itself, along with actual or potential foreign suppliers. Plus, in latter days, the environmental and consumer movements.

For some 40 years, the Jones-Costigan Act, with its subsequent amendments, in detail and in name, provided reasonable stability to domestic and foreign sugar supplies and prices, at little or no cost to the ultimate consumer. Each segment of the sugar industry had specific responsibilities, and they were generally met. The domestic grower was under restraints relating to acreage, wages and working conditions. The processors had access to demarked supplies of specified origin. The consumers were afforded a reasonably stable price. Figure 1 illustrates the relative prices of raw and refined sugar and of three consumer items in the past decade. Graph lines trace the periods pre-expiration and post-expiration of the U.S. Sugar Act in 1974.

Figure I

PRICES OF RAW AND REFINED SUGAR AND SUGAR-CONTAINING CONSUMER ITEMS FOR A DECADE CENTERED ON THE EXPIRATION OF THE U.S. SUGAR ACT



An important aspect of the Sugar Act has been omitted in recent legislative discussions. The United States exercised considerable persuasion in foreign relations through sugar importation quotas. A U.S. sugar quota was a guarantee of foreign exchange, in dollars, and nations vied with each other for better, or larger, quotas. Allocation of quota deficiencies offered secondary opportunities. Importantly, the import quotas were based upon U.S. consumption estimates, less anticipated domestic production.

A "Special Study on Sugar" commissioned by the House Committee on Agriculture in the 87th Congress, 1961, notes: "A quota system represents the highest degree of control among the alternative approaches. Our present quota system imposes detailed regulation upon the marketing of domestic and foreign sugar and, through that mechanism, the attainment of certain price objectives. This broad approach has the capability of insuring a steady flow of supplies and a high degree of stability, which effectively isolates the U.S. sugar market from the world market."

The particular mechanism selected under the Sugar Act was especially suitable, since most of the world's sugar was traded under "international conventions." The small portion traded on the so-called open or world market was characterized by widely variable and unpredictable supplies and prices. In a section entitled "Free Trade" the aforementioned Special Study noted that "substantial repercussions" would occur with a free trade policy, including "irregularity of supplies, particularly in periods of crisis," the price of sugar would "drop to a lower level, would be somewhat variable, and in times of crisis might move to a higher level," and "a substantial part of the domestic industry would be eliminated." And, these predictions have been fulfilled.

For nearly 150 years prior to 1934, the United States relied on a tariff system for sugar; from 1934 until 1974 the quota system was the basic approach to achieving sugar policy goals. What term describes the U.S. sugar position since 1974? Has there been a position or policy since 1974?

Table 1 summarizes approximate annual values for successive levels of sugar transactions. Several columns are of special interest. The value of raw sugar, duty paid, at New York, and the U.S. retail price column reflect modest and reasonably stable prices for more than 20 years, until the eve of the expiration of the Sugar Act. The column "Index, U.S. Retail NY Raw" was obtained by dividing the annual retail price by the corresponding raw price. The overall average index for the 33-year period included in the table is 1.69. Ninety-four percent of the annual indices, for 31 of 33 years, are within the range 1.48 to 1.90. The indices suggest a general factor for determining retail price regardless of raw sugar prices.

The final paragraphs of these political nuances must be concerned with a common event, dumping. Stanley E. George noted in his Presidential Message (1979) to the Sugar Industry Technologists that "the United States is the only industrialized country in the world that seems to be hell-bent on destroying its domestic sugar industry." Travel down that road has been facilitated by U.S. refiner purchases of European sugars at US $0.07 per pound. These transactions have been followed by European governmental payments to the shippers of US $0.14 per pound. Is the value of the shipped sugar not US $0.21 per pound? Do these transactions not constitute dumping?

For the world's population, food is necessary and can be enjoyable. Food which is merely filling is sufficient when stress or need are great, but food offers aesthetic satisfaction beyond the physical need in affluent and sophisticated circumstances. One facet of current American life is the appeal and demand for "convenience foods," which require little or no preparation, and no creative activity, by the housewife or consumer. A second facet is the proliferation of kinds and numbers of "fast food" chains and the increasing frequency of "eating out" or meals away from home. The consumer may complain about the high cost of food, but ignores the expense of preparing and placing the food items on a frozen TV-dinner tray or in a paper bag at a take-out window. The true food cost may be relatively low compared to the price the consumer is willing to pay for time or convenience. Agriculture grew the food, but did not create the circumstances, nor is agriculture responsible for prices inflated through the processing and vending of retail items.

Under these conditions, the American consumer becomes increasingly remote from the original or raw food product and agriculture. Perhaps he "couldn't care less." After all, food is still a relative bargain and little effort was required to drive-in and be fed. It is not necessary for the consumer to recognize that each "farmer" feeds 50 or more persons on the average; that efficient, productive agriculture has released much of our population from the chores of growing and harvesting food and freed people for industrial and service occupations. Only three percent of the American population is involved in food production and 90 percent of that food production derives from one percent of the population. No nation can be strong without a strong agricultural base; agriculture is the foundation of the economy of the United States.

Agricultural publications may trumpet the foregoing comparisons among a plethora of similar facts and superlatives which illustrate agricultural capacity. We have been talking among ourselves. Bumper stickers in agricultural areas proclaim: "Agriculture feeds you three times a day." But, the mission is greater; agriculture must educate, as well as feed, the American population.

Sugar receives continuing attention from the pseudonutritionists, food faddists and consumer groups who, with strident, arrogant cries and without license, claim to represent the general population. One faction proclaims that all sugar is bad and that all human health suffers from the use of sugar. Eating a ripe

McIntosh apple or another sweet fruit is not decried. A second group claims that refined sugar is bad, but that brown sugar contains worthwhile mineral nutrition and is healthy. This second group cannot, or will not, recognize that refined sugar is 99.9 percent sucrose and that raw brown sugar is more than 96 percent sucrose. Polarization of raw sugar producedin Florida in recent years has averaged higher than 98.2 percent. For practical purposes, this indicates content of 98.2 or more percent sucrose and 1.8 or less percent water and mineral matter. Mineral nutrition requirements cannot be satisfied by eating raw sugar.

Table I

Approximate Annual Values, in Cents Per Pound, for Successive Levels of Sugar Transactions

Year	World Price	Raw Sugar Duty Paid, New York	Index, Refiners' Margin	Retail Spread	US Retail Price	US Retail/ NY Raw
1945	$0.031*	$0.038	$0.011	$0.013	$0.067	$0.018
1946	0.042*	0.046	0.012	0.013	0.077	0.017
1947	0.050*	0.062	0.014	0.016	0.097	0.016
1948	0.042	0.055	0.015	0.018	0.094	0.017
1949	0.042	0.058	0.015	0.017	0.095	0.016
1950	0.050	0.059	0.014	0.019	0.098	0.017
1951	0.057	0.061	0.016	0.019	0.101	0.017
1952	0.042	0.063	0.016	0.019	0.103	0.016
1953	0.034	0.063	0.017	0.020	0.106	0.017
1954	0.033	0.061	0.019	0.020	0.105	0.017
1955	0.032	0.060	0.019	0.020	0.104	0.017
1956	0.035	0.061	0.020	0.020	0.106	0.017
1957	0.052	0.062	0.022	0.021	0.110	0.018
1958	0.035	0.063	0.023	0.022	0.113	0.018
1959	0.030	0.062	0.024	0.023	0.114	0.018
1960	0.031	0.063	0.024	0.024	0.116	0.018
1961	0.029	0.063	0.024	0.026	0.118	0.019
1962	0.030	0.065	0.024	0.023	0.117	0.018
1963	0.085	0.082	0.030	0.019	0.136	0.017
1964	0.059	0.069	0.030	0.023	0.128	0.019
1965	0.021	0.067	0.027	0.018	0.118	0.018
1966	0.019	0.070	0.026	0.019	0.120	0.017
1967	0.020	0.073	0.026	0.018	0.122	0.017
1968	0.020	0.075	0.026	0.015	0.122	0.016
1969	0.033	0.077	0.029	0.012	0.124	0.016
1970	0.038	0.081	0.031	0.013	0.130	0.016
1971	0.045	0.085	0.032	0.014	0.136	0.016
1972	0.074	0.091	0.032	0.011	0.139	0.015
1973	0.096	0.103	0.030	0.013	0.151	0.015
1974	0.296	0.291	0.036	(0.010)	0.323	0.011
1975	0.205	0.225	0.080	0.064	0.372	0.017
1976	0.116	0.133	0.055	0.052	0.240	0.018
1977	0.082†	0.110	0.061	0.047	0.216	0.020

* For years 1942-1947 inclusive based on prices paid by CCC, a U.S. Government agency, which purchased Cuba's export surplus in those years, annual averages are final average settlement prices.

† January - October, 1977.

Note--Based on U.S. Department of Agriculture Sugar Statistics and Lamborn's Charts of World Sugar Prices.

A consequence of consumer remoteness from, and minunderstanding of, food production can be seen in environmental extremism, ecohysteria rather than ecoreason. Control or prudent use of agrichemicals is desirable, but that fact does not imply that agrichemicals are bad. Judicious use is intelligent and economical. Our laws have developed in a way which permits. and sometimes specifically demand, increasing public participation in the rule-making processes. A legal forum is available also, through individual and class-action lawsuits. Perhaps, public participation became a new form of "town meeting" when originated. Unfortunately, those who participate may represent a small, but vocal, portion of the populace. The process, undoubtedly, dilutes the responsibility of elected officials. Liberal use of inexpensive lawsuits has permitted a recent action which seeks to prohibit a western university from using public funds to conduct research in agriculture labor-saving technologies, which may displace field labor and which allegedly contribute directly to the economic benefit of investors in agricultural operations.

A litany of similar tales is available for the making. With friends such as our consumers, who needs enemies?

Table II

Thousands of Hectares of Sugar Cane Harvested for Sugar Per Crop or Calendar Year. Approximate

YEAR	FLORIDA	LOUISIANA	HAWAII
1944-1945	10.8	98.4	41.2
1945-1946	12.4	93.6	33.6
1946-1947	12.8	102.	45.2
1947-1948	14.	103.6	40.
1948-1949	14.	109.6	43.6
1949-1950	14.8	111.6	43.6
1950-1951	14.8	109.2	43.6
1951-1952	15.6	103.2	43.2
1952-1953	17.2	109.6	43.2
1953-1954	18.	112.	42.8
1954-1955	15.6	98.8	42.4
1955-1956	14.	92.8	42.8
1956-1957	12.	81.2	42.8
1957-1958	13.2	90.4	33 6
1958-1959	13.6	87.6	44.
1959-1960	18.4	100.	41.6
1960-1961	19.6	102.	43.2
1961-1962	22.4	110.8	43.6
1962-1963	45.6	101.6	42.8
1963-1964	57.2	118.4	44.4
1964-1965	88	130.	44.
1965-1966	74.	115.2	44.4
1966-1967	76.4	115.2	44.8
1967-1968	76.4	117.6	45.6
1968-1969	72.8	112.8	45.2
1969-1970	61.2	94.	45 6
1970-1971	68.	106.4	46.4
1971-1972	76.	120.4	43.2
1972-1973	97.6	124.4	43.2
1973-1974	103.2	127.6	38.4
1974-1975	103.2	123.2	42.
1975-1976	114.8	123.2	40.
1976-1977	114.4	116.4	38.8

Note: Values based on HSPA Sugar Manual, 1978

Table III

Tonnes of Sugar Cane Harvested Per Hectare for Sugar Per Crop or Calendar Year, Approximate

YEAR	FLORIDA	LOUISIANA	HAWAII
1944-1945	64.8	45.	160.65
1945-1946	74.7	49.275	159.975
1946-1947	73.35	39.6	158.175
1947-1948	60.075	33.975	169.65
1948-1949	64.575	43.2	166.275
1949-1950	69.3	40.275	168.075
1950-1951	70.425	43.875	174.15
1951-1952	72.9	38.925	180.9
1952-1953	78.525	46.575	186.975
1953-1954	73.35	46.35	197.55
1954-1955	73.35	51.3	209.025
1955-1956	75.15	54.9	208.575
1956-1957	89.325	53.325	199.125
1957-1958	93.825	49.5	202.05
1958-1959	85.05	49.5	191.925
1959-1960	85.95	45.675	187.2
1960-1961	71.55	49.275	199.35
1961-1962	81.45	57.825	203.4
1962-1963	79.65	47.025	210.15
1963-1964	70.2	65.025	213.3
1964-1965	65.925	51.075	220.5
1965-1966	65.475	51.075	222.3
1966-1967	71.55	51.075	222.075
1967-1968	77.175	62.1	223.65
1968-1969	66.375	58.725	215.325
1969-1970	76.05	54.225	206.775
1970-1971	75.15	58.725	207.675
1971-1972	71.325	48.15	206.1
1972-1973	85.725	58.05	200.7
1973-1974	70.875	46.35	213.3
1974-1975	65.25	47.925	202.95
1975-1976	79.425	47.25	206.55
1976-1977	73.35	57.6	209 25

Note. Values based on HSPA Sugar Manual, 1978.

Preoccupation with sugar prices in recent years has obliterated production from the consciousness of many industry leaders. But, sugar crops must be produced before they can be sold. Tables I, II, and III list the hectares of sugar cane harvested for sugar, tonnes of sugar cane per hectare, and kilograms of 96 degree sugar per tonne of cane for Florida, Louisiana and Hawaii. The tonnes of cane per hectare and kilograms of sugar per tonne cane values indicate no substantial change, and do not suggest advance, in recent decades. Rather, within each producing area, the variations apparently reflect the effects of local events, climatic and otherwise, rather than those of trend.

According to McCloud (1977), sugar cane production has shown the smallest increase in yield of any of the Florida crops, only 1.2 fold since 1928. He notes that weather-induced tonnage fluctuations are extremely high and that sugar cane was the least yield-stable of the crops studied. According to his analysis, there is little tendency for improvement in tonne-per-hectare yields. Is the same conclusion applicable elsewhere? Has domestic sugar cane production reached a plateau? Is there no opportunity for improvement in tonnes of cane or sugar per hectare? Sugar cane scientists should make a clear cautionary statement if we have reached or are approaching productive maxima, and should identify the limiting factor(s). Under such circumstances, our research goals must be reorganized toward management which will achieve maximum economic yield in terms of sugar per hectare per month.

The strength of the sugar industry has been its ability to produce. Shouldn't we devote "equal time" to growing the crops?

A PLAYBACK

Wildavsky (1979) asks, "Should people be allowed to take risks?" when commenting on the effect of over-cautious attitudes to new technological developments. The fourth paragraph of his article reads:

"The richest, longest-lived, best protected, most-resourceful civilization, with the highest degree of insight into its own technology, is on its way to becoming the most frightened. Has there ever been, one wonders, a society that produced more uncertainty more often about everyday life? It isn't much, really, in dispute--only the land we live on, the water we drink, the air we breathe, the food we eat, the energy that supports us. Chicken Little is alive and well in America. Evidently, a mechanism is at work ringing alarms faster than most of us can keep track of them. The great question is this: Is there something new in our environment or is there something new in our social relations?"

Clearly, there is something different, if not new, in our societal affairs. We have taken risks deeper than the false uncertainties quoted above. Agriculture, in general, and the sugar cane industry, in a parochial sense, must establish or reestablish urban relationships. We must relate facts and dispute myths more effectively; we must integrate our political being into state and national affairs successfully; and, we must enhance our productive capability. The challenges are real and clear, we must meet them through mutual goals and close cooperation.

Table IV

96 Percent Raw Sugar Made Per Tonne Cane Per Crop or Calendar Year, Approximate

YEAR	FLORIDA	LOUISIANA	HAWAII
1944-1945	88	75	111.5
1945-1946	96	72	113.5
1946-1947	90.5	74	110
1947-1948	86.5	76	110.5
1948-1949	79	75	119
1949-1950	132.5	83	117.5
1950-1951	132.5	85	117.5
1951-1952	97.5	66	117.5
1952-1953	103.5	79.5	122
1953-1954	103.5	83	114
1954-1955	105	85	115.5
1955-1956	102	80.5	111
1956-1957	107	89	115
1957-1958	100.5	79.5	101.5
1958-1959	104	91	103.5
1959-1960	99	87	108.5
1960-1961	102.5	84.5	114
1961-1962	102	91.5	114
1962-1963	94	89	109.5
1963-1964	95.5	88.5	112.5
1964-1965	89	77.5	113.5
1965-1966	100.5	84	112.5
1966-1967	107.5	85.5	108
1967-1968	109.5	91	109
1968-1969	101.5	90.5	109
1969-1970	102.5	94.5	111
1970-1971	115	87	115
1971-1972	105.5	88.5	112.5
1972-1973	103.5	82.5	117
1973-1974	101.5	85	114.5
1974-1975	112.	90.5	116.5
1975-1976	103.5	99	114.5
1976-1977	94	87	115

Note: Values based on HSPA Sugar Manual, 1978.

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PRESIDENT'S MESSAGE: LOUISIANA DIVISION

Roland M. Hebert
St. Martin Cooperative, Inc.
St. Martinville, Louisiana

This year, 1979, brings to an end another decade of the U.S. sugar industry. It has been a decade that has left this great industry scarred, and, perhaps, limping but not permanently crippled. The strength, courage, vision and endurance of the industry and its producers and processors will not allow this. We look to the next decade with guarded optimism and a more vocal concern for our self-interest and preservation.

The 1970's have not been extremely kind to the Louisiana sugar industry. 1970 itself was ushered in by terrible harvest conditions accompanied by early freezes. The bonanza year, 1974, drove the price of sugar to a record high; this event placed the sugar industry in an envious profit position. The envy was short lived, however, since many industrial users of sugar took advantage of the moment by escalating the price of their products, because of the increase in the price of sugar. Needless to say, the cost of their products did not take the subsequent downward spiral which has been suffered by the sugar industry since 1974.

The expiration of the U.S. Sugar Act and the unsuccessful attempts to legislate new sugar legislation are now a part of the industry's legacy for the 1970's. In addition to the continued downward trend in the price of sugar, the energy shortage has forced the Louisiana sugar industry to spend thousands of dollars on combination fuel burners for the boilers, installation of pre-heaters and other energy-saving schemes devices. There is small consolation in the fact that, while the sugar industry is doing its part to consume less energy, the cost of production continues to increase, while profits decrease.

In the past decade, we witnessed a concerted effort by growers to implement recommendations to increase the raw sugar yield per acre by methods such as wide-row planting, installation of the core-sampler testing system, and the aggressive use of new cane varieties.

In the 1970's, we also saw the cost of labor and materials rise to unparalleled levels. A minor improvement in a factory has become a major financial undertaking. On an even sadder note, the Louisiana sugar industry has seen the number of raw sugar houses decrease from 43, in 1970, to 25, in 1979. Sugar production rose from 541,800 tonnes in 1970 to 601,200 tonnes in 1977, but dropped back down to 495,000 tonnes in 1978. Sugar cane acreage went from 114,400 hectares in 1970 to 136,400 hectares in 1973, back down to 118,400 for the 1978 crop.

We cannot allow this to continue.

It is difficult to believe that the government leaders in this great nation will allow the sugar situation to deteriorate to the point at which we see the oil industry today. Have not their experiences with oil taught them a lesson on the folly and danger of becoming dependent on imports? Their short-term thinking regarding the oil industry, if extended to our sugar industry, will indeed be disasterous.

Provided with accurate information, one wonders whether consumers, in general, would be as upset about a possible rise in the price of sugar as the anti-sugar legislation advocates claim they would be. Industrial sugar users naturally have a vested interest and want cheap sugar. However, John Q. Public is well aware that, while the price of a Hershey bar went up in 1974 because of high costs of sugar, that same Hershey bar kept getting smaller and more expensive, while the price of sugar dropped drastically. In 1974, we could put US $0.10 or $0.15 in a Coca-Cola machine and receive a soft drink. Today, the same machine requires $0.30 to $0.50 for the same soft drink.

Anti-sugar advocates have done an excellent job of "selling a bill of goods" to the American public. No real, unbiased effort has been made to inform the consumers that most nations of the world have long-term contracts for their sugar, and that the dumping ground for excess, uncommitted sugar is the world market, which represents approximately 10 to 15 percent of the total world sugar production. Few sincere people outside the sugar industry realize that the U.S. sugar price is tied to this low world-price sugar. Yet, the domestic sugar growers and processors are compelled to compete with the low world price of excess sugar, while stimultaneously meeting the requirements for minimum wage rates, complying with OSHA standards, dealing with the inflated cost of equipment and supplies, and paying for the operation of an unsupportive government.

The consumer, likewise, is not being told of the double standards that control the price of domestic sugar. He is falsely being led to believe that cheap, imported foreign sugar is part of the answer for decreasing our weekly food bill. If, in fact, this is so, why are all farm commodities suffering the pangs of inflation? Consumers need to be levelled with. The costs of all goods and services have increased, and continue to increase daily. What is not being publicized sufficiently to those outside the sugar industry is the long-range danger of the domestic sugar market being absorbed by imported sugar and the reality of the U.S. being at the mercy of foreign producers, who do not know or care about the cost of operating the U.S. government through its tax structure, who do not employ thousands of U.S. citizens, who do not purchase millions of dollars of U.S.-manufactured equipment, supplies, goods and services, who do not grow and process their sugar under Environmental Protection Agency (EPA) requirements, and who have no loyalty, except to themselves.

Sugar policy in the U.S. has resembled an "Alice in Wonderland" fantasy since the demise of the Sugar Act. Roller-coaster prices led to the enactment of the de la Garza loan program in 1977. Properly administered, this could have been an effective interim program. Instead of using import quotas and fees effectively, as instructed by Congress, the Administration dilly-dallied and, finally, issued regulations which were often counterproductive to the intent of the legislation.

A complex payment program for the 1977 crop sugar was instituted, but the regulations were changed so often, and so many questions were raised about its legality, that final payments for the 1977 crop still have not been made, even as this message is written.

After sugar legislation was defeated in 1978, President Jimmy Carter personally assured Senator Russel B. Long and others that the market price for sugar would be supported at $0.15 per pound, pending passage of new legislation. This promise has not been kept. In fact, import fees were actually decreased on April 1, 1979, despite the fact that U.S. sugar prices were substantially below $0.15 per pound. In spite of this ridiculous result of the Administration's fee-setting mechanism, the President has refused to change either the mechanism or the fee.

President Carter has set such narrow constraints on the type of sugar bill he will sign that sugar producers have had difficulty reaching an agreement on legislation. Issues such as payments and wage provisions have led to heated debates within the brotherhood of domestic sweetener producers. It is hoped that any scars from such debates will heal quickly, and be soon forgotten. The domestic sugar industry cannot afford division within its own ranks.

We all owe a debt of gratitude to those members of our industry who have spent substantial time and effort trying to negotiate and pass sweetener legislation. We, in Louisiana, especially appreciate the dedicated efforts of American Sugar Cane League's President, P. J. deGravelles, Jr., and James Thibaut, who is Chairman of the League's National Legislation Committee.

Obviously, there is much that we must strive for in the decade which follows:

* We most certainly need to continue to strive for a price for sugar which will result in a stable and viable domestic sugar industry.

* We need to explore an entry into the energy arena through the production of alcohol if, and I emphasize if, the cost of disposing of the by-products is not prohibitive, and if the volume allows a reasonable return on capital investments.

* We need to initiate technological improvements in wiser and more profitable use of sugar products and by-products.

* We need to encourage plant scientists to develop sugar cane varieties producing 14,000 pounds of sugar per acre (15.75 tonnes per hectare) in combination with close and wide-row planting.

* We need to develop an internal public relations program to accurately inform our consumers of our plight.

* We need to maintain a serious dialogue with congressional, governmental, and consumer groups which are influential in areas affecting our industry and its concerns.

I doubt seriously that I would be standing here today if it were not for the continuous support and encouragement of numerous people in our sugar industry.

It has been said that there is a time to sow and a time to reap, and that one reaps what one sows. If this is in fact so, I look forward to a bountiful harvest. We have put forth our best efforts to sow. It is logical, then, that we must reap an equitable return for our product. Long live Sugar!

GROWTH RATES OF FLORIDA SUGARCANE DURING SEVEN GROWING SEASONS[1]

G. Kidder
University of Florida
Agricultural Research and Education Center
Belle Glade, FL
and
E. R. Rice
U. S. Sugarcane Field Station
SEA, AR, Canal Point, FL

ABSTRACT

Sugarcane height measurements taken weekly from April through October at Canal Point, FL, showed that the plants grew most rapidly from mid June to early July, peaking on the average near 15 cm (5.9 in)/week. Growth rates decreased in an almost linear fashion from July through October, when measurements were discontinued. Rates in late October generally averaged 8 cm (3.1 in)/week. Average height in October was 2.8 m (9.2 ft), representing an average growth rate of 9 cm (3.5 in)/week during the grand growth period. Varieties showed different growth rates, but all had the same general pattern of growth, accelerating rapidly in April and May, peaking in June and July, and tapering off until flowering or harvest.

INTRODUCTION

Plant height measurements, because they are non-destructive and relatively easy to make, are frequently used as an index of growth. Sugarcane producers use height to gauge the growth rate of their cane, for detecting growth problems, and for estimating yields. Stalk length is an important component of yield of millable cane (4) and is correlated with characteristics such as erectness of cane (2). The rapidity with which cane grows, especially early in the growing season, affects weed control and is one of the agronomic characteristics evaluated in the variety development program (6,7). The varietal growth pattern can also be important in studies of environmental factors, growth regulators, and in mathematical modeling of sugarcane growth.

This paper is a preliminary report on a study, conducted at Canal Point, Florida, of the growth patterns of several sugarcane varieties.

MATERIALS AND METHODS

The study was conducted annually from 1968 through 1975, with the exception of 1972. Five varieties of cane were planted between late November and mid-January of each year. Plots consisted of single rows 3 m (10 ft) long located along the field edge. There was a 0.6 m (2 ft) space between plots (varieties). Varieties chosen were popular or promising at the time they were included in the experiment (Table 1). All data available for a given variety were included in the averages.

Table 1. Varieties studied in each of the seven years of the experiment.

Variety	Year						
	1968*	1969	1970	1971	1973	1974	1975
Cl 41-223	X	X	X	X	X	X	X
CP 50-28	X						
CP 56-59					X	X	X
CP 56-63	X	X	X				
CP 57-603		X	X				
CP 62-374	X	X					
CP 63-306			X	X	X	X	X
CP 63-588		X	X	X	X	X	X
CP 65-357							X
CP 66-1079				X	X	X	
L 61-49				X			

*Data of one variety were discarded because of mistaken identification of the variety.

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[1] Florida Agricultural Experiment Stations Journal Series No. 2387.

Table 2. Average weekly elongation (measured to top visible dewlap) of five sugarcane varieties at Canal Point, Florida

Week of Year*	Variety				
	Cl 41-223 (N=7 yr)	CP 63-588 (N=6 yr)	CP 63-306 (N=5 yr)	CP 56-59 N=3 yr)	CP 65-357 (N= 1 yr)
	cm/week**				
14	1.0	2.0	2.0	4.5	4.5
15	0.5	3.0	2.5	3.5	5.0
16	1.5	3.0	2.0	3.5	6.5
17	1.5	4.0	3.0	4.0	8.5
18	2.5	4.5	4.0	4.0	16.0
19	3.0	5.5	5.5	6.0	18.0
20	4.0	7.0	6.5	6.5	16.0
21	5.5	7.5	7.0	8.0	16.5
22	6.0	9.5	9.0	11.0	14.0
23	7.5	10.5	11.0	11.0	11.5
24	11.0	13.5	14.0	14.0	17.0
25	11.5	13.5	15.5	12.5	12.0
26	13.0	13.0	15.5	14.5	14.0
27	13.5	13.5	15.0	13.5	11.0
28	13.5	13.0	16.0	15.0	11.0
29	12.0	12.5	15.0	13.5	10.0
30	12.5	13.0	16.0	14.5	8.0
31	12.5	12.0	14.5	14.0	8.5
32	11.5	11.0	14.0	13.0	12.0
33	12.0	11.5	13.0	13.5	10.0
34	11.0	10.5	12.5	12.5	9.0
35	9.5	9.5	10.0	10.0	8.5
36	9.5	9.0	10.0	11.0	9.0
37	10.0	10.0	10.5	13.0	8.5
38	9.5	10.0	11.0	11.0	9.5
39	10.0	10.5	11.0	13.0	-
40	9.5	9.0	8.5	11.5	-
41	8.0	8.5	11.0	7.5	-
42	8.0	9.5	11.0	5.5	-
43	7.5	8.0	10.5	-	-

* Weeks No. 14, 27, and 43 correspond approximately with the first week of April, the first week of July, and the last week of October, respectively.

**To convert to English system, multiply cm by 0.394 to obtain inches.

The measurements made in this study covered what is generally considered the grand growth period of Florida sugarcane. During that time, established plant cane grew from ground level to 2.8 m (9.2 ft), an average of 0.40 m (1.3 ft)/month or 9 cm (3.5 in)/week. Because this value is the result of nearly 10,500 measurements made over a period of seven years on 11 varieties, the authors consider it to be a good approximation of the average growth rate of sugarcane under the conditions of south Florida.

Ten representative plants were selected and measured from soil surface to the top visible dewlap (TVD) on Wednesday of each week. Measurements were begun the first week of April, the time when appreciable growth began in most years, and were continued through October when flowering started or harvest commitments took precedence. If one of the selected stalks was found damaged (e.g., from the sugarcane borer), an undamaged stalk of approximately the same height was chosen as a replacement stalk. Measurements made on lodged or curved stalks followed the contour of the stalk; thus, stalk length rather than height was measured late in the growing season.

RESULTS AND DISCUSSION

The average weekly growth measured during the seven years of the experiment is shown in Figure 1. It can be seen that the growth in early April was quite slow, less than 2 cm (0.8 in)/week. Growth accelerated rapidly in May and peaked near 15 cm (5.9 in)/week in late June and early July. Growth then gradually declined to 8 cm (3.1 in)/week by the end of October. It is interesting to note that there was still appreciable growth occurring when measurements were suspended in late October.

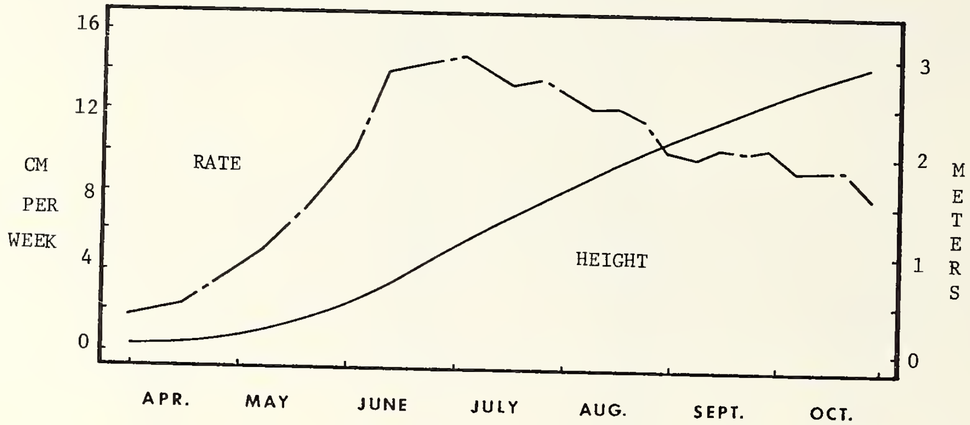

Figure 1. Seven-year average growth rate (cm/week) and height (meters) of sugarcane. Each week's point on the curve is the average of 350 measurements.

The weekly growth rates of five varieties are presented in Table 2. These varieties represented 64% of the hectarage planted to sugarcane in Florida in 1979 (5). The rapid early growth characteristic of CP 65-357 is evident in the one year's data available for that variety, which was released to Florida growers in 1975. The average weekly growth of 6.1 and 16.6 cm (2.4 and 6.5 in) in April and May, respectively, measured for CP 65-357 were far greater than those measured for the other varieties at that time of year. Both CP 63-588 and CP 56-59 exhibited similar growth patterns -- moderately rapid early growth (3.4 and 6.1 cm/week in April and May, respectively) and rapid growth (12.8 and 13.5 cm/week) in June and July. The relatively slow early growth of Cl 41-223 can also be noted in the data. Variety CP 63-306 was slower growing than CP 63-588 early in the season but maintained a higher rate from June through the rest of the growing season.

The average height of all cane measured during the seven years of the study is plotted in Figure 1. The resulting sigmoid curve is similar to classic sugarcane growth curves (3). The shape of the growth rate curve (Figure 1) resembles that of cane grown under tropical conditions more closely than any previously reported curves for cane growth at Canal Point (1). During relatively warm winters, Florida cane will continue to elongate into January. The early-flowering variety, CP 62-374, grew at a rate of 7.5 cm (3.0 in)/week right up to the time of spiking in mid-October.

Average heights of the five varieties discussed earlier are presented in Table 3. The tallest-growing variety in the test was CP 65-357, which maintained the height advantage gained early in the season even after the weekly growth rate fell below that of other varieties in mid-June. Varieties CP 56-59 and CP 63-306 were essentially the same height from mid-July through the end of the season, with CP 63-306 overcoming a slower early season growth rate. Height of the cane in late October ranged from 2.5 m (8.2 ft) for Cl 41-223 to 3.1 m (10.1 ft) for CP 63-306.

Table 3. Average height of five sugarcane varieties growing at Canal Point, Florida between April and October

Week of Year*	Variety				
	Cl 41-223 (N=7 yr)	CP 63-588 (N=6 yr)	CP 63-306 (N=5 yr)	CP 56-59 (N=3 yr)	CP 65-357 (N= 1 yr)
	cm**				
14	1.0	2.0	2.0	4.5	4.5
15	1.5	5.0	4.5	8.0	9.0
16	3.0	8.0	6.5	11.0	15.5
17	5.0	12.0	9.5	15.5	24.0
18	7.0	16.5	14.0	19.0	40.0
19	10.5	21.5	19.5	25.0	58.5
20	14.5	28.5	25.5	31.5	74.5
21	19.5	36.0	33.0	39.5	90.5
22	26.0	46.0	41.5	50.5	105.0
23	33.5	56.5	53.0	61.5	116.0
24	44.5	70.0	66.5	75.0	133.5
25	55.5	83.5	82.0	87.5	145.0
26	69.0	96.5	97.5	102.5	159.0
27	82.5	110.0	113.0	116.0	170.0
28	96.0	123.0	128.5	131.0	181.0
29	108.0	135.5	143.5	144.5	191.5
30	121.0	148.5	159.5	159.0	199.0
31	133.0	160.0	174.0	172.5	208.0
32	144.5	171.0	188.0	185.5	219.5
33	156.5	182.5	201.0	199.0	230.0
34	167.5	193.0	213.5	211.5	239.0
35	177.0	202.5	223.5	222.0	247.5
36	186.5	211.5	233.5	233.0	256.5
37	196.0	221.0	244.0	245.5	265.0
38	205.5	231.0	255.0	256.5	274.5
39	215.5	241.5	266.0	269.5	-
40	225.0	250.5	275.0	281.0	-
41	233.0	259.0	286.0	288.5	-
42	241.0	268.5	297.0	294.5	-
43	248.5	276.5	307.5	-	-

* Weeks No. 14, 27, and 43 correspond approximately with the first week of April, the first week of July, and the last week of October respectively.

** To convert to English system, multiply cm by 0.394 to obtain inches.

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THE RELATIONSHIP BETWEEN THE NITROGEN CONTENT OF MEDIUM-COARSE TO MEDIUM-FINE TEXTURED SOILS AND YIELD RESPONSE OF STUBBLE SUGARCANE TO FERTILIZER NITROGEN

Laron E. Golden
Agronomy Department
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

Yields were obtained from 38 field tests with stubble sugarcane at locations in the Mississippi River, Bayou Lafourche and Bayou Teche areas of production. The tests were conducted on medium-coarse to medium-fine textured soils. Increases in yield due to fertilizer N were determined by comparing yield from the check and from the N-treated plots at each location. During 1958-60, the rate of N applied was 120 lb per acre and during 1961-71, the rate of N was 160 lb per acre. Total N contents of topsoil were obtained from each test site. The mean yield from check plots was 21.49 tons per acre and the mean increase in yield due to fertilizer N was 6.95 tons per acre. The mean N content of topsoil was .092%. Relatively low N contents were found among the coarser textured soils when compared to the finer textured soils. The lowest N content of soil, .062%, and the highest, .154%, were associated with yield increases of 3.92 and 9.37 tons per acre, respectively. A statistically significant positive correlation (r = .323) was obtained between topsoil N contents and yield response due to fertilizer N. The correlations between topsoil N and cane yield from the check (r = -.281) and between topsoil N and cane yield from the treated plots (r = -.077) were not significant. The relatively low yields from check plots on the finer textured soils were apparently due, in part, to low oxygen contents and poor root development in the subsoil.

INTRODUCTION

Sugarcane is produced primarily on medium-coarse (light) to medium-fine (heavy) textured soils in Louisiana. Soils with very high amounts of fine-textured components are generally brought into, or removed from, sugarcane production when increases, or decreases, in acreages are desired.

In 1958, for plant cane, 40 to 60 lb of nitrogen (N) per acre were recommended on medium-coarse to medium-textured soils, and 60 to 80 lb of N per acre were recommended on fine-textured soils. For stubble cane, 80 to 100 lb of N per acre were recommended for all soil types (2).

In 1978, for plant cane, 60 to 100 lb of N per acre were recommended on medium-coarse to medium-textured soils, with the lower amounts suggested for weak stands (low plant population) and the higher amounts for strong stands (high plant population). The recommendation for plant cane grown on fine-textured soils was 80 to 120 lb of N per acre. Rates of N recommended for stubble cane varied from 100 to 140 lb per acre on medium-coarse to medium-textured soils and from 120 to 160 lb per acre on medium-fine to fine-textured soils (1, 3, 7).

Results from field tests with stubble cane on finer textured soils, in which the highest rate of N was either 200 or 240 lb per acre, showed some increases in yield from rates of N above the rate of 160 lb per acre but they were generally too small to be considered economically important (3).

Patrick el al (6) reported relatively high oxygen contents and good root development by sugarcane at depths below 6 inches in the relatively coarse-textured soils, Commerce and Cypremort, and low oxygen contents and poor root development in fine-textured soils from the Mhoon, Sharkey, Baldwin and Iberia series.

The purpose of this study was to determine the relationship of total amounts of N in topsoils to yield response of stubble cane to fertilizer N.

MATERIALS AND METHODS

Yield data were obtained from 38 field tests with stubble sugarcane at locations in the Mississippi River, Bayou Lafourche and Bayou Teche areas of production. Information showing soil type, year and variety at each test site is shown in Table 1.

At test sites 1 through 8, yields from the check or no-fertilizer treatment were compared with yields from the treatment which received 120 lb of fertilizer N per acre, and at the other sites, yields from the check were compared with those where the rate of N was 160 lb per acre.

Generally, the plot size was one-tenth acre or larger and the source of N was ammonium nitrate.

A topsoil sample was obtained from the check at each new test site at the time of fertilization in the spring. The samples were analyzed for total N contents by the modified Kjeldahl method. Each of the tests, 6, 12, 17, 27, and 38, was repeated on the same site as the previous year and, since soil N contents vary very little annually (4), topsoil N values from the previous year were reported.

Table 1. Experimental locations, soil types, year and varieties of sugarcane.

Test Number	Plantation	Soil type	Year	Variety
1	Alice "B"	Baldwin sil	1958	CP 44-101
2	Smithfield	Mhoon sil	1958	CP 48-103
3	Little Texas	Mhoon sil	1958	CP 36-105
4	Pecan Tree	Mhoon sicl	1958	CP 44-101
5	O'Neil	Baldwin sicl	1959	CP 44-101
6	Little Texas	Mhoon sil	1959	CP 36-105
7	Smithfield	Commerce sil	1960	CP 36-105
8	Pecan Tree	Mhoon sicl	1960	CP 44-101
9	Alice "B"	Cypremort l	1961	CP 52-68
10	Little Texas	Mhoon sil	1961	CP 52-68
11	Pecan Tree	Mhoon sicl	1961	CP 44-101
12	Little Texas	Mhoon sil	1962	CP 52-68
13	Alice "B"	Baldwin sil	1963	NCo 310
14	Georgia	Mhoon sil	1963	CP 52-68
15	Laurel Grove	Mhoon sicl	1963	CP 52-68
16	Alice "B"	Baldwin l	1964	CP 52-68
17	Laurel Grove	Mhoon sicl	1964	CP 52-68
18	F. A. Graugnard & Sons	Mhoon sicl	1964	CP 52-68
19	Myrtle Grove	Commerce sil	1965	CP 52-68
20	Laurel Ridge	Mhoon sil	1965	CP 52-68
21	Laurel Grove	Mhoon sicl	1965	CP 52-68
22	Myrtle Grove	Commerce sil	1966	CP 52-68
23	Laurel Grove	Mhoon sic	1966	CP 52-68
24	Evan Hall	Commerce sil	1967	CP 48-103
25	Myrtle Grove	Mhoon sil	1967	CP 47-193
26	Upper Ten	Mhoon sil	1967	CP 55-30
27	Laurel Grove	Mhoon sic	1967	CP 52-68
28	Little Texas	Mhoon sicl	1967	NCo 310
29	Simonaud	Jeanerette sil	1968	NCo 310
30	Kilgore	Jeanerette sil	1969	NCo 310
31	Belleview	Baldwin sicl	1969	CP 52-68
32	St. James	Mhoon sil	1969	CP 55-30
33	Evan Hall	Mhoon sicl	1969	L 60-25
34	Belleview	Baldwin sicl	1970	CP 52-68
35	Evan Hall	Mhoon sil	1970	CP 48-103
36	St. James	Mhoon sicl	1970	L 60-25
37	O'Neil	Baldwin sicl	1971	CP 52-68
38	Evan Hall	Mhoon sil	1971	CP 48-103

RESULTS AND DISCUSSION

Topsoil N and sugarcane yield data are contained in Table 2. The lowest amount of topsoil N, .062%, was found in Test No. 9, which was conducted on a Cypremort loam, and the highest, .154%, was in Test No. 28 on a Mhoon silty clay loam. Yield increases due to fertilizer N in those tests were 3.92 and 9.37 tons per acre, respectively. The mean yield increase from all tests, 6.95 tons per acre (32%), was highly significant.

Figure 1 shows the relationship between topsoil N contents and cane yield increases which were due to fertilizer N. The correlation was low (r = .323) but was statistically significant.

The correlations between topsoil N and cane yield from the check (r = -.281) and between topsoil N and cane yield from the treated plots (r = -.077) were not significant.

The data in Table 3 show means of soil N and sugarcane yields from medium-coarse to medium and from medium to medium-fine textured soils. The means were calculated from data in Table 2. Of the 38 test locations, 22 were on medium-coarse to medium-textured soils (loam and silt loam) and 16 were on medium- to medium-fine textured soils (silty clay loam and silty clay). From the information presented in Table 3 it can be seen that the mean yields from treated plots on the coarser and finer textured soils were approximately equal, and that the greater mean increase from the tests on finer textured soils was associated with a relatively low mean yield from the checks. The difference in mean yields from check plots on the coarser and finer textured soils, 3.96 tons per acre, approached significance. The difference in mean increases in yield on the coarser and finer textured soils, 4.18 tons per acre, was significant.

Table 2. The relationship of soil nitrogen to sugarcane yield.

Test Number	Topsoil N	Cane yield		
		Check	Treated[1]	Increase over check
		Net tons/acre		
1	.089	17.60	21.30	3.70
2	.064	18.70	24.10	5.40
3	.066	16.90	25.40	8.50
4	.147	9.34	17.08	7.74
5	.125	17.60	28.20	0.60
6	.066	14.40	19.00	4.60
7	.067	20.60	25.40	4.80
8	.095	22.80	30.40	7.60
9	.062	27.88	31.80	3.92
10	.068	25.60	32.00	6.40
11	.095	21.28	26.47	5.19
12	.068	14.65	19.20	4.55
13	.071	27.29	38.57	11.28
14	.086	36.76	41.12	4.36
15	.105	29.26	37.09	7.83
16	.069	28.09	28.59	0.50
17	.105	18.48	25.05	6.57
18	.142	17.64	33.59	15.95
19	.077	24.22	31.31	7.09
20	.071	19.89	29.85	9.96
21	.105	14.64	23.66	9.02
22	.085	25.91	29.93	4.02
23	.093	16.64	31.66	15.02
24	.077	40.85	41.36	0.51
25	.081	21.59	25.82	4.23
26	.095	23.71	33.08	9.37
27	.093	20.94	38.45	17.51
28	.154	24.19	33.56	9.37
29	.109	22.79	25.55	2.76
30	.108	14.38	18.12	3.74
31	.097	16.20	23.34	7.14
32	.085	16.89	20.99	4.10
33	.096	18.86	32.19	13.33
34	.090	20.51	28.29	7.78
35	.088	30.09	37.14	7.05
36	.121	15.80	19.80	4.00
37	.112	22.99	28.41	5.42
38	.088	20.63	23.98	3.35

[1] Treated with fertilizer N.

Table 3. Means of soil nitrogen contents and sugarcane yields from medium-coarse to medium and from medium to medium-fine textured soils.

Soil texture	Mean topsoil N	Mean cane yield		
		Check	Treated	Increase over check
	%	Net tons/acre		
Medium coarse - medium [1]	.079	23.16	28.35	5.19**
Medium - medium fine[2]	.111	19.20	28.57	9.37**

** Significant at the 1% level of probability.

[1] Means are from all test locations shown in Table 2 where soils were classed as loam (l) and silt loam (sil).

[2] Means are from all test locations shown in Table 2 where soils were classed as silty-clay loam (sicl) and silty-clay (sic).

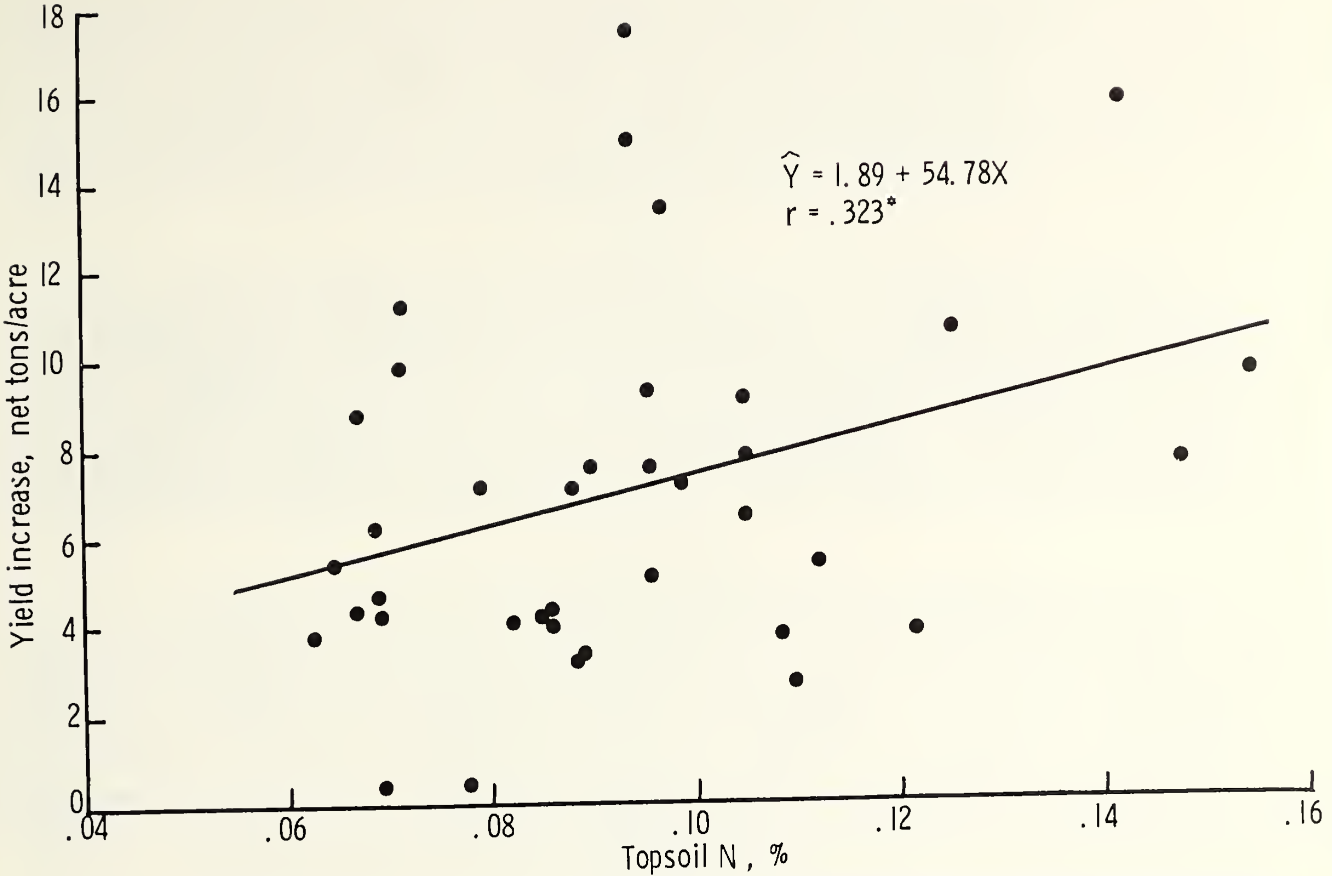

Fig. l. The relationship of topsoil N contents and sugarcane yield increases as influenced by fertilizer N.

The tendency for lower yields to occur in check plots on the finer textured soils (Tables 2 and 3) was apparently due, in part, to poorer nutrition as influenced by low oxygen contents and poor root development in the subsoil (6). The generally higher yield responses to fertilizer N on the finer textured soils were apparently due to the greater dependence of the sugarcane roots on N in the topsoil, supplied largely from fertilizer. A factor that may have favored yield increases on finer textured soils is the probability that leaching losses during the growing season, following application of N, were lower than on coarser textured soils, and were sufficiently lower to exceed any relatively greater losses of N that may have occurred by volatization from finer textured soils during short periods of high soil moisture content.

In a separate study (5), where fertilization and variety treatments were constant, above-ground parts of stubble cane grown on Baldwin silt loam (relatively coarse-textured) contained 3.63 lb of N per ton of millable cane or 143.0 lb per acre at harvest and, on Iberia clay (fine-textured), contained 3.07 lb of N per ton of millable cane or 112.5 lb per acre at harvest. The LSD (.05) values were .19 lb per ton of millable cane and 9.0 lb per acre. Cane yield on the Baldwin soil was 39.40 tons per acre and on the Iberia soil was 36.66 tons per acre. The LSD (.05) for cane yield was 2.45 tons per acre.

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USING FUNGICIDES ON MECHANICALLY HARVESTED SUGARCANE SEEDPIECES TO INCREASE YIELDS

B. R. Eiland
Agricultural Engineer, USDA, SEA, AR, Sugarcane Harvesting Research Unit
Belle Glade, Florida

Jack L. Dean
Plant Pathologist, USDA, SEA, AR, Sugarcane Field Station
Canal Point, Florida

ABSTRACT

Two levels of two fungicides and a check without any fungicide were applied to two seedpiece lengths of two sugarcane varieties in a factorial experiment to measure their effect on shoot emergence, final stalk population, and resultant yield. Plant populations were determined from initial germination to harvest. Seedpiece length and fungicide treatment were found to influence shoot emergence, final stalk populations, and cane yield. No yield differences were found with the lower seed application used this year and the higher seed application rate used last year in similar treatments. The best treatment combination appeared to be the lower level of captafol applied to the long seedpieces. The yield from long seedpieces that received this treatment was 18 percent higher than that of the untreated long seedpieces. It appears that furrow-spraying of captafol on mechanically harvested seedpieces will increase cane yields at harvest.

INTRODUCTION

Increasing stalk populations within a sugarcane variety generally offers a means of increasing tonnage yields and, thereby, lowering production costs per ton. Researchers in addition to the present authors have reported that the use of fungicides increased stands of cane (1,2,3). The fungicides have usually been applied by dipping the seedpieces in a solution. Previously we reported on the use of two fungicides, captafol and benomyl applied by spraying, which increased plant population but did not increase tonnage yield at harvest (5). The lack of yield difference was attributed to excellent stands of sugarcane in all test plots. Another experiment was planned in which the planting rate was reduced to obtain a lower stand. We decided to plant only a single continuous line of cane and to test two levels of each of two fungicides, capafol and guazatine. Guazatine was found to increase populations in South Africa in some instances (2). The objective of this experiment was to determine whether a fungicide applied by spraying in the furrow would increase both plant populations and yields from mechanically harvested seedpieces.

PROCEDURES

We considered three factors that could influence stalk population and cane yield: (a) variety, (b) seedpiece length, and (c) fungicide. The experimental design was a split-plot block in which varieties were main plots and combinations of the fungicides and seedpiece lengths were subplots. Main plots were replicated four times. Subplots were single rows 8 m long and 1.7 m wide, separated within a row by a 1-m alleyway.

The treatments in the experiment consisted of combinations of two sugarcane varieties (CP 63-588 and CP 65-357), two average seedpiece lengths (short and long), and two levels of two fungicides (captafol at 971 and 1941 ml/km of row length and guazatine at 21 and 42 ml/km of row length) and a check for which no fungicide or spray was applied. We purchased the captafol as a commercially available liquid formulation containing 0.481 kg/l of active ingredient. The guazatine was supplied as a liquid containing 60 percent active ingredient. Application rates are based upon the liquid formulation as supplied.

We used a Massey-Ferguson 201 [1] chopper harvester in the experiment to cut the seed cane and to cut the cane at harvest. The short seedpiece length used (24.3 ± 5.4 cm) was the average length normally delivered by the harvester, and the long seedpiece length used (42.2 ± 10.1 cm) was obtained by removing one set of the chopping knives from the harvester. Seed material was planted as delivered by the harvester, and about 11 percent of the eyes had been damaged by the harvester.

Seed material was harvested and planted in organic soil at Canal Point, Florida, on January 5, 1978. One continuous line of cane, half the normal planting rate, was laid in the open furrows, and the plots were hand-sprayed with fungicide before the seed cane was covered. A constant amount of water (122.5 l/km of row length with captafol and 78.5 l/km of row length with guazatine) was applied for each fungicide treatment. The liquid fungicides were mixed with water and applied by using hand sprayers equipped with pressure gauges. A constant pressure was maintained in the sprayer, and a worker simply walked back and forth applying the spray to each plot for a certain time to obtain uniform coverage.

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[1] Trade names or company names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agriculture or an endorsement by the Department over other products not mentioned.

Between the beginning of shoot emergence and harvest, the stalks in each plot were counted 12 times, the interval depending upon the expected population change. The cane was harvested on December 21, 1978, and the cane from each subplot was weighed. Standard statistical procedures (analysis of variance and lsd means for treatment differences) were used to determine significant differences between populations and between cane yields resulting from the different treatments (6).

RESULTS

Shoot populations increased rapidly, as is normal in Florida during early summer, and peaked during the latter part of June. As stalks became shaded and died, populations then decreased rapidly until the end of August, leveled off until October, and then decreased again slightly between October and harvest in December (data not shown). Results of the statistical analysis (analysis of variance F values) of the data are shown in Table 1. The varieties exhibited large differences because they were selected for diverse stalk and growing characteristics. Seedpiece length and fungicide treatment were the two factors that affected stalk population within each variety over the growing season. Both factors decreased in significance as the growing season progressed, but were still highly significant at harvest. High populations in early growth resulted in high populations and high cane yields at harvest. The most important result, and one which we did not find in the previous experiment (5), was that cane yield was affected by the fungicide treatments.

Table 1. Analysis of variance F values for 12 population counts and final yields for two sugarcane varieties, two seedpiece lengths, and two fungicides at two levels compared with a check.

Dates	Variety	Length	Fungicide	VxL	VxF	LxF	VxLxF
02/24/78	205***	49***	8***	10***	3*	3*	2
03/10/78	35**	55***	10***	19***	4*	3*	4**
03/21/78	12*	27***	8***	18***	3*	2	2
04/05/78	1	33***	8***	3	1	3*	--
04/20/78	8	83***	9***	5*	--	3*	6***
05/05/78	29*	53***	8***	4	--	3*	5***
05/19/78	49**	33***	5***	2	--	2	--
06/01/78	84**	24**	4**	2	--	1	--
06/15/78	147**	20***	4**	2	--	1	--
07/08/78	70**	6*	4**	--	--	1	--
08/30/78	79**	22***	2	--	--	1	--
12/20/78	168**	12***	6***	2	1	2	5***
Final Yield	12*	23***	10***	2	4**	5***	12***

V = Variety, L = Length, F = Fungicide
* = Significant at the 0.05 level
** = Significant at the 0.01 level
*** = Significant at the 0.005 level

Previous studies (4,5) indicated that seedpiece length affects shoot emergence. At 75 days after planting, we found similar results in this experiment; long seedpieces produced 24 percent more shoots than the short seedpieces (Table 2). The average number of emerged shoots after the captafol treatments was 24 percent greater than that for the treatments without any fungicide. The guazatine treatments did not increase shoot populations over those of treatments without any fungicide. Analysis of the variety X length means showed that long seedpieces of CP 63-588 produced more shoots than did short seedpieces of that variety. The analysis also showed no differences in shoot emergence of CP 65-357 with respect to seedpiece length. Analysis of the variety X fungicide means on other earlier counting dates showed that the fungicide treatments on the long seedpieces enhanced shoot emergence more than they did on the short seedpieces, a result not readily explainable.

Stalk populations at harvest followed shoot emergence trends. The long seedpieces produced 13 percent more stalks at harvest than those of the short seedpieces (Table 3). The captafol treatments averaged 11 percent more stalks at harvest than those of treatments without any fungicide. The guazatine treatments did not increase stalk population at harvest over those of treatments without any fungicide.

Table 2. Shoot populations (1000/ha) 75 days after planting for two sugarcane varieties, two seedpiece lengths, and two fungicides at two levels and a check, Canal Point, Florida.*

Variety	Seedpiece Length	Check	CAPTAFOL		GUAZATINE	
			(971 ml/km)	(1941 ml/km)	(21 ml/km)	(42 ml/km)
CP 65-357	Short	12.3	12.3	13.2	10.7	11.2
	Long	10.9	13.2	14.9	12.3	11.2
CP 63-588	Short	12.9	17.1	13.1	12.5	7.9
	Long	14.7	22.8	19.7	16.1	19.2
FUNGICIDE AVG. (lsd 0.05 = 1.8)		12.7	16.4	15.2	12.6	12.1

* Each treatment value shown represents the average of four replications.

Table 3. Stalk populations (1000/ha) at harvest for two sugarcane varieties, two seedpiece lengths, and two fungicides at two levels and a check, Canal Point, Florida.*

Variety	Seedpiece Length	Check	CAPTAFOL		GUAZATINE	
			(971 ml/km)	(1941 ml/km)	(21 ml/km)	(42 ml/km)
CP 65-357	Short	79.0	80.7	82.5	78.7	77.4
	Long	78.5	95.8	85.3	83.6	89.9
CP 63-588	Short	62.7	72.2	70.0	63.4	54.2
	Long	71.1	83.8	77.8	74.8	74.1
FUNGICIDE AVG. (lsd 0.05 = 4.9)		72.8	83.1	78.9	75.1	73.9

*Each treatment value shown represents the average of four replications.

Gross cane yields at harvest are shown in Table 4. These yields compared very favorably with those we reported previously for seedpieces without heat treatment at twice the seed application rate (5). At harvest, the yield from long seedpieces was 8 percent greater than that from the short seedpieces. Both captafol treatments and the low level of guazatine treatment averaged 9 percent higher cane yields than those of treatments without any fungicide. The higher level of guazatine did not increase cane yield over that of treatments without any fungicide and cannot be recommended. Analysis of the length X fungicide means showed that the low level of captafol applied on the long seedpieces produced more cane yield at harvest than any other fungicide treatment applied to long seedpieces. With this treatment cane yield was 18 percent higher than that from the long-seedpiece treatments without any fungicide. Within the short seedpieces, both captafol treatments and the low level of guazatine increased cane yields over those resulting from treatments without any fungicide. The yield from short seedpieces that received the higher level of guazatine was less than that of the short-seedpieces that received no fungicide treatment.

Table 4. Gross yields (t/ha) at harvest for two sugarcane varieties, two seedpiece lengths, two fungicides at two levels, and a check, Canal Point, Florida.*

Variety	Seedpiece Length	Check	CAPTAFOL		GUAZATINE	
			(971 ml/km)	(1941 ml/km)	(21 ml/km)	(42 ml/km)
CP 65-357	Short	118.6	122.1	132.7	126.5	116.1
	Long	113.9	138.3	127.9	134.7	135.3
CP 63-588	Short	125.1	135.5	126.2	136.2	103.4
	Long	131.8	152.8	144.2	129.4	130.4
FUNGICIDE AVG. (lsd 0.05 = 6.3)		122.3	137.2	132.8	131.7	121.3

* Each treatment value shown represents the average of four replications.

CONCLUSION

The application of a captafol spray to mechanically harvested seedpieces lying in opened furrows before covering appears to enhance shoot emergence, to increase stalk populations at harvest, and to increase cane yields. The yields compared favorably with those reported previously for seedpieces planted at twice the rate used in this study. Further research to determine the optimum levels of captafol or other fungicides for furrow-spraying on mechanically harvested seedpieces is needed.

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THE EFFECT OF PLANTING DATE ON YIELD AND ITS COMPONENTS OF SUGARCANE IN THE LOWER RIO GRANDE VALLEY OF TEXAS

Sim A. Reeves, Jr.
Associate Professor, Texas Agricultural Experiment Station
Weslaco, Texas

ABSTRACT

Historically, fall planting of sugarcane was a common practice in South Texas during the early 1900's though there is little reference to planting dates in the existing literature (6). In the early 1970's, Cowley (5) observed differences in growth and development of cane planted on different dates; however, a comprehensive study to determine the optimal planting dates was not undertaken at that time. In their feasibility study for the re-establishment of a sugarcane industry in the Lower Rio Grande Valley, F. C. Shaffer and Associates (15) selected fall or early winter planting dates in the projection of production and harvesting schedules.

Research in other areas has shown differential varietal response in yield to changes in planting dates (2, 4, 8, 13). Arceneaux (2,3), working in Louisiana, found that fall planting dates produced better yield and the most productive planting date differed among varieties. Later, Matherne (8, 9) found the same significant interaction between varieties and yield of cane and sugar per hectare at different planting dates. Still in Louisiana, Fanguy and Benda (7) showed that spring plantings produced yields considerably below those of the same varieties planted in the fall.

Elsewhere, higher yields of cane were obtained in the Imperial Valley of California from August and October plantings than from those plantings made in November and December (4). Ramos and Milo (13) reported differential varietal response to planting dates with the varieties NCo 310 and NCo 376 in Mozambique on the continent of Africa.

It has become apparent in recent years that information on optimal planting dates be determined for the major varieties grown in South Texas to maximize yield. This paper will show the effects of four planting dates on yield components of five sugarcane varieties in the Lower Rio Grande Valley of Texas.

METHODS AND MATERIALS

With the development of the Texas sugarcane enterprise, programs to develop optimum production practices early indicated the further need of definitive data relative to planting date and varietal response interactions. Trials were conducted at Weslaco, Texas, to study the effects of planting dates on yield components of five varieties of sugarcane during the 1975-76 and 1976-77 production seasons.

1975-76 Trials

The effect of planting date on yield components was studied in randomized complete block experiments with four replications.

The five varieties selected for study along with their maturity classifications are as follows: Early: L62-96, CP 57-614; Mid-Season: CP 65-357, CP 61-37; and Late: NCo 310.

The test site was routinely prepared for the plantings as scheduled. The seed cane of each variety was double line planted at 152 cm row spacings. The plots were four rows wide and 9.2 m in length. Nitrogen fertilizer was applied at 68 kg/ha and all plots were irrigated as needed. Insect control measures were applied as infestation levels warranted; and all plots were maintained relatively free of weeds.

Planting dates and the number of days from planting to harvest are shown in Table 1. Harvest date for all plots was December 15, 1976.

1976-77 Trials

The procedures followed in conducting the trials in 1976-77 were identical to those of 1975-76. The planting dates, number of days to harvest and harvest dates are shown in Table 1. However, it should be noted that the first planting date was a month earlier in the fall and the last planting date was a month later in the spring; the growing season was extended at one end of the planting cycle and correspondingly shortened at the other.

Table 1. Planting dates and number of days to harvest for a two-year period.

Planting Dates	No. Days to Harvest	Harvest Dates
	1975-76	
November 17, 1975	393	December 15, 1976
December 15, 1975	364	December 15, 1976
February 9, 1976	309	December 15, 1976
March 17, 1976	273	December 15, 1976
	1976-77	
October 10, 1976	426	December 13, 1977
February 18, 1976	311	December 13, 1977
March 22, 1977	279	December 13, 1977
April 29, 1977	241	December 13, 1977

The two inside rows of each plot were hand cut for yield measurement. A 15-stalk sample was taken from each plot and milled once through a 3-roll mill for juice quality determinations. Brix was measured by hydrometer, pol by polarization and purity as the relationship of pol to brix (Meade-Chene). June analyses were made by the SEA, USDA, Food Crops Utilization Research Laboratory, Weslaco, Texas. Stalk heights were recorded from the base of the plants to the topmost mature internode; individual stalk weight was computed as the average weight of the 15-stalk samples. The 15-stalk samples were hand cleaned for determination of trash percentages.

Both experiments were analyzed as completely randomized designs with four replications per treatment. Duncan's multiple range test was conducted on both trials.

RESULTS AND DISCUSSION

A review of weather records in the Lower Rio Grande Valley would tend to indicate the feasibility of fall planting dates. Daily normals of temperature at Weslaco, Texas, in the mid-Valley area for January, the coldest month of the year, show an average minimum temperature of 51.2^{o}F. From 32 years of record, however, thee were 11 occurrences of temperatures of 32 degrees or below in the spring season to indicate the probability of foliage damage. Records relative to mean monthly soil temperatures are incomplete; however, a February-March average based on limited data is shown as 66.6^{o}F with the average soil temperature some 4.4^{o}F warmer than air temperature. It follows then that once plant cane root systems are established from fall plantings, there is little probability of destruction from freezing air temperatures; regrowth potentials following destruction of top growth may well differ with varieties.

1975-76 Trials

As adapted from meteorological records compiled by the Texas Agricultural Experiment Station at Weslaco, Texas data relative to critical temperatures are presented in Table 2. There was but one day with temperature below freezing, a minimum of 29^{o}F recorded on January 8; no frosts were recorded during the period November, 1975, through April, 1976.

Table 2. Monthly mean minimum temperatures, number of days with 40^{o}F and below, absolute minimum temperatures and date of occurrence during the period October through April. 1/

	October	November	December	January	February	March	April
				1975-76			
Monthly Mean Minimum	63.8	57.3	51.0	48.8	55.1	61.8	65.7
No. Days 40^{o}F and Below	0	3	4	5	3	0	0
Absolute Minimum Temp.	55^{o}	37^{o}	36^{o}	29^{o} 2/	39^{o}	46^{o}	51^{o}
Date of Occurrence	4	27	19	8	1	17	1
				1976-77			
Monthly Mean Minimum	59.1	50.6	48.3	45.7	51.6	60.0	63.5
No. Days 40^{o}F and Below	0	3	3	11	2	0	0
Absolute Minimum Temp.	50^{o}	39^{o}	34^{o}	29^{o}2/	37^{o}	41^{o}	49^{o}
Date of Occurrence	30	14	3	10	16	8	5

1/ Meteorological Record, Texas Agricultural Experiment Station, Weslaco, Texas.

2/ Frost recorded.

The data compiled from the trials conducted in the 1975-76 season are presented in Table 3.

Table 3. The effects of four planting dates on yield parameters of five sugarcane varieties at Weslaco, Texas, 1976. [1]

Planting Dates	NCo 310	CP 65-357	CP 61-37	CP 57-614	L 62-96
		Yield of Cane per Hectare (m Tons)			
November 17, 1975	124.10 a [2]	85.79 C	88.26 c	80.19 c	64.74 d-f
December 16, 1975	108.64 b	62.05 d-h	77.28 cd	73.02 c-e	48.16 gh
February 9, 1976	80.19 c	38.38 e-h	58.46 gh	63.39 d-g	49.28 gh
March 17, 1976	77.28 cd	46.37 h	53.76 f-h	47.71 gh	49.95 gh
		Yield of Sugar per m Tons (kg)			
November 17, 1975	107 f	114 d	108 f	121 b	100 e
December 16, 1975	111 e	120 b	107 f	124 a	114 d
February 9, 1976	115 d	110 e	114 d	125 a	118 c
March 17, 1976	118 c	118 c	117 c	124 a	117 c
		Yield of Sugar per Hectare (m Tons)			
November 17, 1975	13.28 a	9.78 c	9.53 c	9.70 c	7.12 fg
December 16, 1975	12.06 b	7.45 fg	8.27 d-f	9.06 c-3	5.49 ij
February 9, 1976	9.22 cd	5.32 j	6.66 g-i	7.92 e-g	5.82 h-j
March 17, 1976	9.12 cd	5.47 j	6.29 gh	5.92 h-j	5.84 h-j
		Average Stalk Weight (kg)			
November 17, 1975	1.20 c	1.27 c	1.17 d	1.50 b	1.86 a
December 16, 1975	1.18 d	1.02 e	1.14 de	1.27 c	1.41 b
February 9, 1976	0.85 f	0.82 f	0.91 f	0.91 f	1.04 de
March 17, 1976	0.73 g	0.73 g	0.73 g	0.82 f	0.82 f
		Height of Stalk (cm)			
November 17, 1975	191 a	180 ab	175 b	191 a	188 a
December 16, 1975	175 b	168 bc	162 bc	178 ab	168 bc
February 9, 1976	153 cd	145 cd	138 e	170 bc	155 c
March 17, 1976	140 de	145 cd	142 de	147 cd	150 cd

[1] Harvest date: December 15, 1976.

[2] Means followed by different letters differ significantly at P - 0.01.

The varieties, NCo 310, CP 65-357 and L 62-96 produced significantly greater seasonal yields from the November planting than at any later planting date.

The yields of the December plantings of NCo 310 and CP 61-37 were significantly greater than those harvested from February and March plantings; within varieties, the yields produced from February and March plantings were not significantly different.

NCo 310 was significantly superior to the other varieties in yields at all planting dates, but the yields of CP 65-357, CP 61-37, CP 57-614 and L 62-96 were not significantly different at harvests of the February and March plantings.

Data relative to stalk heights are indicative of a decreasing trend in growth with delayed planting dates; however, only in NCo 310 was this trend significantly consistent throughout the planting cycle. There were no significant differences in the heights of cane plants harvested from February and March plantings.

With exception of CP 61-37 from the harvests of November and December plantings, the average stalk weights showed a significant decreasing trend with the delay in plantings.

In yields of sugar per ton of cane, recoveries with NCo 310 demonstrated significant upward trends with delayed planting dates; the yields of CP 65-357 were significantly higher from the December planting; the greatest yield of CP 61-37 was obtained from the March planting. The yields of CP 57-614 were the highest of all varieties at all planting dates but did not differ significantly at the harvests of the last three planting dates.

Within varieties, sugar yields per hectare for all but CP 57-614 and L 62-96 were significantly greater from harvests of the November planting. The yields of NCo 310, CP 65-357, and CP 61-37 from the December planting were greater than those of the February and March plantings; L 62-96 and CP 57-614 exceptions, without significant differences between yields from December and January plantings. Sugar yields of NCo 310, CP 65-357, CP 61-37 and L 62-96 did not vary significantly in harvests of the February and March plantings.

1976-77 Trials

Temperature data recorded during the 1976-77 planting cycle are shown in Table 2. Monthly Mean Minimum Temperatures, Number of Days with 40° F and Below, Absolute Minimum Temperatures and Date of Occurence During the Period October 1976 through April 1977. Temperatures in January and February of 1977 were lower than those of the corresponding months of 1976; frosts recorded on January 3 and on February 10 burned the tender growths of the October planting.

The data recorded from the 1976-77 planting date trials are presented in Table 4. The cane yields harvested in 1976-77 were sharply lower than those of the 1975-76 season.

Within varieties, yields of the October planting were superior to those from later dates. The yields of NCo 310 declined significantly with succeeding planting dates. CP 65-357 was the highest yielding variety at all planting dates; however, the yields were not significantly different at harvests of the last two planting dates. The yields of CP 61-37, highest in the October planting, declined in the February planting and were lower but not significantly different at the last two planting dates. There was sharp reduction in the yields of CP 57-614 with the March and April plantings. The yields of L 62-96 declined at the February planting but were not significantly different at the March and April dates.

Table 4. The effects of four planting dates on yield parameters of five sugarcane varieties at Weslaco, Texas, 1977 1/

Planting Dates	NCo 310	CP 65-357	CP 61-37	CP 57-614	L 62-96
			Yield of Cane per Hectare (m Tons)		
October 10, 1976	78.40 bc 2/	108.42 a	86.24 b	56.22 fg	76.83 cd
February 18, 1977	68.10 de	87.36 b	60.92 ef	40.32 i-k	48.83 g-i
March 22, 1977	39.42 jk	46.59 hi	34.05 j-l	18.14 m	32.26 j-l
April 29, 1977	42.78 h-j	50.62 gh	26.43 lm	21.50 m	35.17 j-l
			Yield of Sugar per m Tons (kg)		
October 10, 1976	115 fg	123 e	129 c	156 a	131 c
February 18, 1977	123 e	128 cd	127 d	156 a	127 d
March 22, 1977	124 de	119 f	124 de	137 b	110 h
April 29, 1977	109 h	109 h	115 fg	126 d	97 i
			Yield of Sugar per Hectare (m Tons)		
October 10, 1976	9.02 b	13.34 a	11.13 a	8.74 d	10.07 a
February 18, 1977	8.38 c	11.18 b	7.74 cd	6.29 ef	6.20 cd
March 22, 1977	4.87 ef	5.54 e	4.22 f	2.49 g	3.55 f
April 29, 1977	4.66 ef	5.52 e	3.04 g	2.70 g	3.41 f
			Average Stalk Weight (kg)		
October 10, 1976	1.21 b	1.11 bc	1.14 b	1.40 a	1.52 a
February 18, 1977	0.86 c	0.65 de	0.83 cd	0.90 bc	0.76 cd
March 22, 1977	0.61 de	0.55 e	0.54 e	0.70 cd	0.60 de
April 29, 1977	0.55 e	0.44 ef	0.46 ef	0.64 de	0.63 de
			Height of Stalk (cm)		
October 10, 1976	277 a	175 c	161 cd	181 b	151 de
February 18, 1977	197 b	151 de	156 cd	125 gh	125 fg
March 22, 1977	149 de	126 fg	126 fg	130 fg	127 fg
April 29, 1977	133 fg	102 gh	113 g	117 gh	113 g

1/ Harvest date: December 13, 1977.

2/ Means followed by different letters differ significantly at P-0.01.

The average stalk heights of NCo 310 decreased with successive planting in the cycle. Plant heights of CP 65-357 showed a similar decrease, with significant reductions through the two earlier plantings. The stalk heights of CP 61-37 from the October and February plantings were not significantly different but declined with the last two dates. The tallest plants of CP 57-614 and L 62-96 were harvested from the October planting.

Average stalk weights of all varieties followed a general trend, decreasing with the successive plantings from that of October. Stalk weights although lower were not significantly different within varieties in harvests of March and April plantings.

The lowest yields of sugar per ton of cane by NCo 310 were produced at the first and last dates of planting. With CP 65-357, the highest yield was produced from the February planting. The sugar yields of CP 61-37 between planting dates were small but significantly lower in the last planting. With CP 57-614, there were declines in the yields of sugar at harvests of the last two plantings. The sugar yields of CP 61-37 between planting dates were small but significantly lower in the last planting. With CP 57-614, there were declines in the yields of sugar at harvests of the last two plantings. The sugar yields of L 62-96 declined significantly with each successive planting date.

Within varieties the highest yields of sugar per hectare were produced from the first two plantings, with those of the October date significantly greater. Sugar yields fell sharply in March and April plantings. With the exception of CP 61-37 with which the April planting date yield was significantly lower, the yields within other varieties were not different at the last two dates.

SUMMARY

The primary objectives of the trials were to evaluate varietal responses to different planting dates and lengths of growing seasons. Obviously studies over a period of years will be required to evaluate the effects of variations within and between seasons.

The data recorded from the trials conducted in 1975-76 and in 1976-77 are consistent in demonstrating the superiority of fall season planting. These data also indicate that very substantial reductions in yield wil be sustained in plantings made later than February.

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THE COMPARATIVE EFFECTS OF PREEMERGENCE HERBICIDES USED IN PLANT CANE IN LOUISIANA

Ernest R. Stamper
Department of Plant Pathology and Crop Physiology
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana 70803

ABSTRACT

Five preemergence herbicides are either labeled or in the process of being registered and labeled for use in Louisiana sugarcane. All five materials have been in tests for several years. There is essentially no difference in the yield of cane or sugar in the five different chemicals. Sinbar, Fenac, and Sencor are registered for use in Louisiana sugarcane. Spike and Velpar are in the process of being labeled, but at the present time, cannot be used in Louisiana sugarcane.

INTRODUCTION

Five preemergence herbicides are either registered and labeled or they are in the process of being registered and labeled for use. All five of the materials have been in field tests in sugarcane for several years. These preemergence materials in some cases have an early postemergence knockdown effect but are considered to be preemergence herbicides.

The purpose of this study was to determine the comparative effect of these herbicides on the yield of sugarcane.

MATERIALS AND METHODS

A large number of tests were made using preemergence herbicides to control weeds and grasses in sugarcane. These studies reflect the comparative yield of sugarcane and do not show the percentage of weed and grass control. The comparisons were made over a period of several years and different varieties of sugarcane were used.

Fenac has been used as a herbicide for a number of years and so has Sinbar. Sencor which is the same as Lexone is the most recently labeled herbicide for use in sugarcane. Sencor-Lexone is the least toxic of all the materials to sugarcane. Spike and Velpar are not registered or labeled for use in sugarcane. Velpar has a very narrow buffer between the rate required to kill grass and the phytotoxic level to sugarcane.

Yields were taken at the normal harvest time.

RESULTS AND DISCUSSION

The data in Table 1 show the yield in tons of sugarcane per acre. There is very little difference in the yield of sugarcane with possibly some injurious effect shown by Velpar in lowering yield.

From these studies it is apparent that Velpar will not become a useful herbicide in sugarcane production in Louisiana. Since Sinbar has the longest residual action, it would be the best to apply on the cane planted in the fall. Sencor is the least toxic to sugarcane and can be used on all soil types at rates higher than is required to give acceptable weed and grass control.

Neither Sinbar nor Sencor is effective in controlling browntop panicum which has become a serious pest in much of the sugarcane growing area. Fenac is the only one of the presently used herbicides that controls the browntop panicum. Data in these studies indicate that a combination of Sinbar and Fenac not only controls browntop panicum but also does not affect the yield of sugarcane when compared with the other herbicides.

Table 1. The comparative yield of sugarcane in tons per acre over a five year period using preemergence herbicides for weed and grass control.

Year	Location and variety	Untreated Check	Sinbar 2/3 lb[1] 80% W.P.	Fenac 4 qts + Silvex 1 lb	Spike 3/4 lb 80%W.P.	Sencor 1½ lb 50% W.P.	Velpar ½ lb 90% W.P.	Sinbar ½ lb Fenac 2 qt
1974	St. Gabriel L 62-96	18.2	25.9	21.5	24.8	21.8	--	--
1974	St. Gabriel CP 65-357	28.6	33.2	33.2	38.6	31.9	--	--
1974	Alma CP 48-103	17.3	35.6	30.8	25.7	28.5	--	--
1974	Alma CP 48-103	17.0	20.6	29.5	29.5	36.4	--	--
1974	Alma CP 48-103	19.6	19.4	30.3	35.8	22.1	--	--
1975	St. Gabriel (1st) CP 62-96	10.3	19.1	17.1	18.0	14.7	--	--
1975	St. Gabriel (1st) CP 65-357	18.1	20.9	28.2	22.7	21.9	--	--
1975	Alma CP 65-357	17.9	31.0	31.9	33.3	30.8	33.0	25.4
1975	Alma CP 48-103	10.8	33.7	33.3	32.2	26.1	23.4	36.0
1976	Magnolia CP 65-357	25.5	27.8	35.2	31.2	33.5	19.3	28.9
1976	Alma CP 65-357	29.2	29.9	29.1	33.1	30.6	34.0	28.7
1976	Allian	20.6	31.5	--	--	28.1	--	--
1976	Alma CP 65-357	36.2	30.0	--	--	36.1	--	--
1977	St. Gabriel CP 65-357	18.1	21.6	21.7	18.2	17.9	24.8	19.0
1977	St. Gabriel CP 67-412	11.8	21.6	25.5	27.6	24.8	17.7	21.0
1977	Alma CP 65-69	22.0	24.5	23.0	21.8	24.8	23.5	21.6
1977	Alma CP 65-357 (1st)	18.1	32.7	29.6	29.3	29.7	29.4	29.0
1978	St. Gabriel CP 65-357	11.3	28.9	35.1	35.2	38.1	27.8	32.6
1978	St. Gabriel CP 67-412	9.5	27.0	34.0	31.0	35.9	21.1	25.0
1978	Alma CP 48-103	21.5	23.5	30.0	15.4	30.1	24.7	22.5
1978	Alma CP 65-357	15.8	30.7	28.9	24.5	29.8	30.6	26.7
1978	Magnolia CP 65-357 (1st)	19.9	26.5	30.3	34.7	28.9	27.3	35.7
1978	Magnolia CP 65-357 (2nd)	17.0	38.6	27.6	38.1	38.3	19.6	40.0
1978	St. Gabriel CP 65-357 (1st)	13.3	29.2	30.2	21.7	32.7	27.4	27.2
1978	St. Gabriel CP 67-412 (1st)	15.5	36.0	34.9	30.9	33.5	29.4	31.2
1978	Alma CP 65-357	15.8	24.5	18.8	22.7	17.9	23.8	16.8
1978	Alma CP 48-103	21.5	23.0	26.3	13.6	24.7	21.0	19.3
	27 tests comparisons (5 yrs) Avg.	18.2	27.7			28.5		
	25 tests comparisons (5 yrs) Avg.	17.7	27.4	28.2	27.6	28.3		
	18 tests comparisons (4 yrs) Avg. All materials	17.5	28.4	29.2	27.5	29.3	25.4	27.0

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[1] Commercial product applied on a 30 inch band.

FACTORS AFFECTING THE OCCURRENCE AND DISTRIBUTION OF FLORIDA WATER RATS IN SUGARCANE FIELDS

David E. Steffen[1]
Dept. of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State Univ., Blacksburg, VA

Nicholas R. Holler[2] and Lynn W. Lefebvre,
U. S. Fish and Wildlife Service
Denver Wildlife Research Center, Gainesville, FL

Patrick F. Scanlon
Dept. of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State Univ., Blacksburg, VA

ABSTRACT

The Florida water rat (Neofiber alleni) is one of several rodent species known to be a depredator of sugarcane grown in southern Florida. Therefore, areas of the United States Sugar Corporation (USSC) and the Okeelanta Division of Gulf and Western Food Products, Inc. were sampled to determine occurrence levels of water rats after the 1975-76 harvest season. Factors potentially influencing the distribution and abundance of water rats were also evaluated in these areas. Water rat populations occurred in 40.3 ± 3.1 (SE) % and 80.4 ± 5.9 (SE) % of the fields in the surveyed area of USSC and Okeelanta, respectively. Populations appeared to be restricted to areas of high soil organic content. Mechanical harvesting and earlier stubble ages inhibited water rat occurrence. Potential control strategies and the underlying biological rationale are suggested by these results.

INTRODUCTION

The Florida water rat (Neofiber alleni) is one of several rodent species known to cause a significant amount of damage to Florida sugarcane (3). The current rodent control technique of baiting field edges is probably ineffective in reducing water rat damage. The burrow systems of this species occur throughout the 15-30 hectare fields, and above ground damage patterns indicate that water rats feed in the vicinity of their burrow systems (3). The Florida water rat was described as a mammal of undetermined status by the U.S. Fish and Wildlife Service (5) and as a Species of Special Concern by the Florida Committee on Rare and Endangered Plants and Animals (4). Control of damage caused by this species, therefore, will require special consideration. The objectives of this study were to determine the occurrence levels of water rats in sugarcane and to investigate factors potentially influencing their distribution.

We gratefully acknowledge the assistance and cooperation provided by J. W. Beardsley, Jr. of USSC, S. Hooks of the Okeelanta Division of Gulf and Western Food Products, Inc., and J. R. Orsenigo of the Florida Sugar Cane League, Inc. Funding for this effort was provided jointly by the Florida Sugar Cane League, Inc., and the U.S. Fish and Wildlife Service.

METHODS

To determine distributional patterns of the Florida water rat, we randomly selected and examined about 25% of the harvested fields belonging to the Western Division of USSC and to the mill lot plantation of the Okeelanta Division of Gulf and Western Food Products, Inc., after the 1975-76 harvest.

To accurately detect the presence of burrow systems, we traversed the fields with a two-wheel drive trail motorcycle at approximately 100 m intervals to provide a good view of the entire field. If possible, fields were observed at least 2 weeks ($\bar{x}$ = 43.1, range = 12-100 days for USSC: $\bar{x}$ = 17.4, range = 3-34 days for Okeelanta) after harvest to allow resumption of normal burrowing activity following this disruption. Some Okeelanta fields had to be searched shortly after harvest to avoid preplanting field preparation.

Water rats form a mound of muck at their burrow entrance. These mounds are flattened and/or covered with trash during the cane harvest. Presence of mounds in the survey fields, therefore, indicated burrowing which had occurred after harvest. Because of the conspicuous nature of water rats' burrows, we believe errors in recording presence or absence of the species were negligible in all areas surveyed.

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[1] Present address: Department of Experimental Statistics, Louisiana State University, Baton Rouge, LA 70803.

[2] Address reprint requests to N. R. Holler.

Other data recorded for each survey field included the stubble age of the field, harvest method (hand or machine) and, at USSC, the soil organic content (provided by E. H. Todd, USSC Research Division). In recording stubble age, plant cane fields were those which were recently planted during late summer or early fall, 1975 (2-4 months before sampling). First stubble fields were those which had not been previously harvested since planting (14-18 months earlier) and which had just undergone first harvest. Second stubble fields had just undergone second harvest (i.e., stubble year reflected the stubble standing at the time of sampling). Second and subsequent stubble fields had 10 to 12 months of growth between harvests. Sampling began January 12, 1976, and was completed March 22, 1976.

RESULTS AND DISCUSSION

Water rat populations inhabited relatively large proportions of surveyed areas in both USSC (40.3%) and Okeelanta (80.4%) sugarcane plantations but appeared to be primarily restricted to one general area at USSC (Table 1, Fig. 1). Low occurrence of the Florida water rat in the other surveyed areas of USSC may have been due to habitat deficiencies. Most fields in the areas of low occurrence (L-area) had been in sugar production since the 1930's, and in general longer than those of the area of high occurrence (H-area). Thus, the L-area did not represent newly created habitat. Also fields inhabited by rats in the L-area had fewer colonies per inhabited field than those in the H-area (Table 1). Nevertheless, it is possible that the L-area represented a region in which an expanding water rat population was becoming established. Consequently, only fields in the H-area were used to investigate characteristics relating to the presence or absence of the water rat.

Virtually all areas of the Okeelanta mill lot which could be sampled contained fields with water rat burrow systems (Table 1). Widespread planting had taken place on the mill lot the preceding summer, consequently 52% of the fields were too tall to be surveyed during our study. The remaining 48% of the fields which could be surveyed were distributed relatively evenly throughout the mill lot and presumably they yielded data representative of the plantation.

Table 1. Florida water rat occurrence after the 1975-76 sugarcane harvest season at USSC and Okeelanta.

	USSC Total survey area[1]	USSC L-area (Low occurrence rate)	USSC H-area (High occurrence rate)	Okeelanta
Number of survey fields	243	74	169	46
Number of water rate inhabited fields	98	5	93	37
Percent (± SC) of fields inhabited by water rats	40.3 (3.1)	6.8 (2.9)	55.0 (3.8)	80.4 (5.9)
$\bar{x}$ (± SC) No. of colonies/ inhabited field[2]	10.0 (1.3)	1.6 (0.4)	10.4 (1.4)	29.9 (5.4)
Acres (ha) surveyed	8,495 (3,438)	2,749 (1,113)	5,746 (2,326)	2,759 (1,117)

[1] See Figure 1.

[2] In comparing values of USSC and Okeelanta, adjustments must be made for field size; $\bar{x}$ sizes (acres) ± SC were: USSC = 35.0 ± 0.9; Okeelanta = 65.7 ± 2.0.

Sampling was not specifically designed to determine how field characteristics (e.g., stubble age, soil organic content) related to the presence and absence of water rat burrow systems. However, certain trends in the percentage of fields inhabited were noted in response to an independent field characteristic (e.g., stubble age) by controlling for a given set of field conditions (e.g., high soil organic content and hand harvested fields). Under these conditions interactions among the independent characteristics could not be detected. Insufficient sample sizes prevented adequate analyses across the range of all variables.

First stubble year fields at USSC had a significantly ($P < 0.001$, $X^2 = 15.78$, 1 d.f.) lower percentage of water rat occurrence than did the pool of all older fields (Figure 2). Only fields with high soil organic content (i.e., $> 80\%$) were used in this analysis to ensure that effects due to variability in soil organic content did not mask a relationship between occurrence and field age. Occurrence rates did not vary significantly ($P = 0.07$, $X^2 = 7.33$, 3 d.f.) between stubble years at Okeelanta; all field ages had high occurrence rates (Figure 3). No plant cane fields at USSC (n = 6) and Okeelanta (n = 4) contained evidence of water rat burrowing activity. Field preparation (discing, flooding, or both) over an extended fallow period probably removes water rat populations in the field before planting of cane.

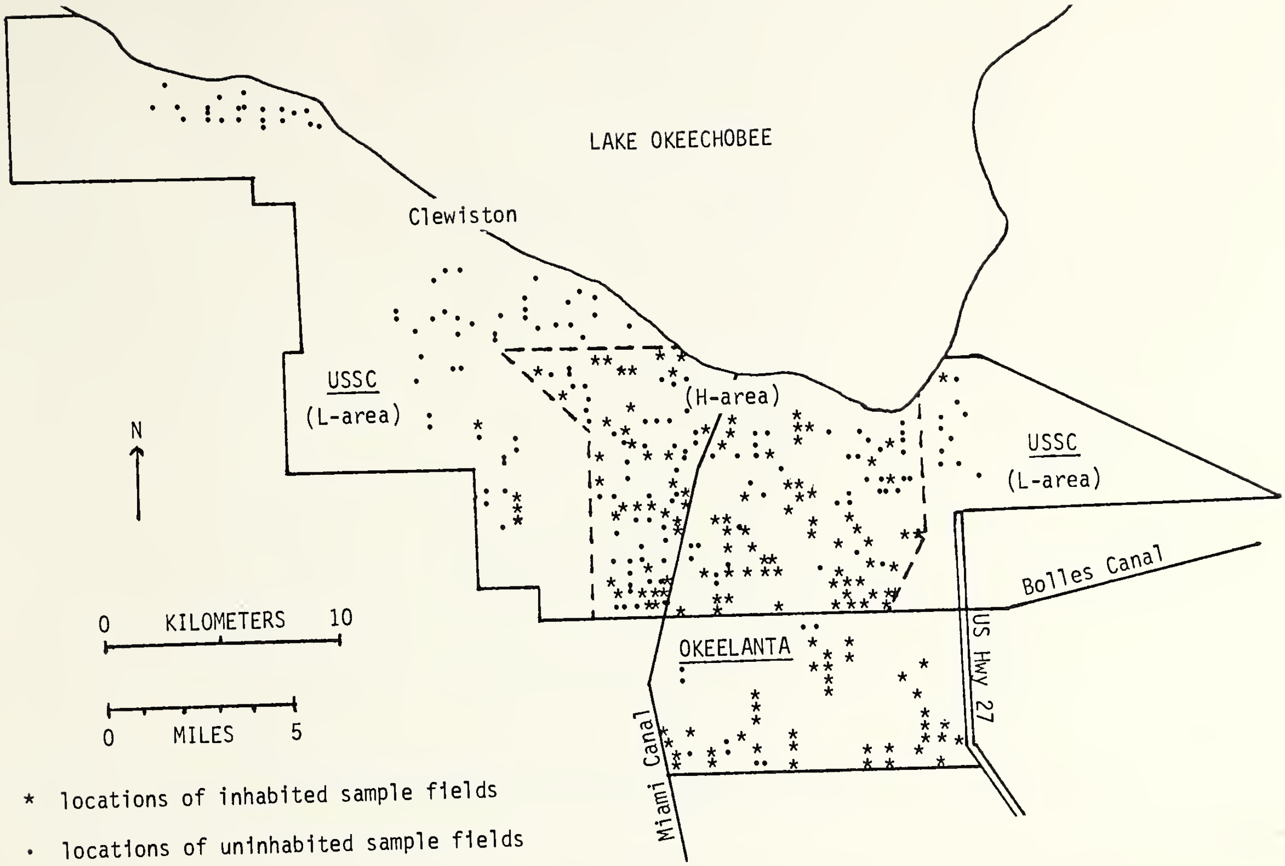

Fig. 1. Study areas for the survey of the distribution and occurrence of the Florida water rat. Area between dashed lines represents high occurrence area (H-area) at USSC. Elsewhere at USSC is the low occurrence area (L-area).

Presence of the Florida water rat was related to soil organic characteristics. In second stubble and older fields of USSC the percentage of fields inhabited by water rats generally increased with higher soil organic content (Figure 4). Fields in the 31 to 60% organic content range had significantly ($P < 0.001$, $X^2 = 16.61$, 1 d.f.) lower occurrence rates than did fields in the 61 to 90% organic content range. No soil organic content data were available at Okeelanta, but soils there generally appeared to be highly organic.

Highly organic soils probably help to maintain burrow and tunnel stability through their friable consistency and high capacity for water retention. Water rat burrowing seemed more prevalent in fields that contained abundant weed growth which may have provided food. This rooted vegetation would also aid in maintaining burrow system integrity. These results tend to support observations of others in sugarcane (2), and in undrained muck of the Everglades, fresh water prairies and marshes, and peat bogs (1).

Hand harvested fields showed a significantly higher ($P < 0.005$, $X^2 = 8.50$, 1 d.f.) water rat occurrence rate than did mechanically harvested fields in the H-area of USSC (84.9% of 66 fields vs 56.0% of 25 fields). Analysis included only fields in second or older stubble having 60% or more organic content. This higher occurrence of water rat burrow systems in hand harvested fields may reflect the water rat's dependence on cover after harvest. Hand harvesting leaves trash (e.g., cane leaves and tops) piled in rows in the field whereas mechanical harvesting removes a much larger proportion of the trash. It is doubtful that the observed difference in occurrence rates is a result of greater direct mortality in machine harvested fields; loaders used in hand harvested fields are actually heavier than the mechanical harvester. All Okeelanta fields were harvested by hand.

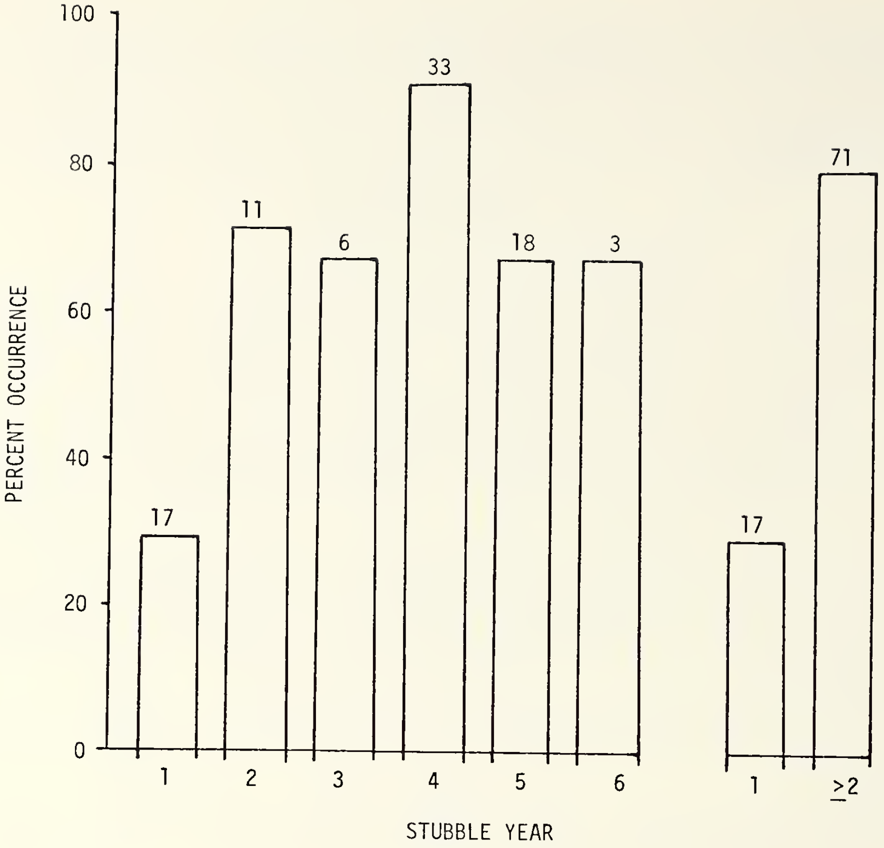

Figure 2. Percentage occurrence of Florida water rats in high soil organic content (> 80%) fields by stubble year in the region of USSC with a high rate of occurrence of Florida water rats after the 1975-1976 harvest season. Numbers at the top of each column represent sample sizes.

Results from an examination of post-harvest burrowing by water rats in a USSC field showed at least a preference for cover after harvest if not a dependency on it (3). In that thoroughly searched field, 544 burrowing openings were found under trash pile rows whereas only 222 burrow openings were found in the same number of trash-free areas. A binomial test showed this difference to be significant ($P < 0.001$, large sample approximation $z = 11.60$).

The L-area of the USSC survey area (Fig. 1) had poorer conditions for water rats than the H-area in terms of organic content and harvest method (Table 2). Soil organic content was significantly lower ($P < 0.001$, $X^2 = 49.86$, 1 d.f.) and a significantly higher ($P < 0.001$, $X^2 = 76.13$, 2 d.f.) percentage of fields were machine harvested. (No significant difference in stubble years was detected between areas.) It is, therefore, probable that unsuitable conditions have prevented water rats from becoming well-established in the uninhabited portions of USSC, rather than that expansion into these areas has not yet occurred.

CONCLUSIONS

The occurrence of the Florida water rat seemed to be inhibited by lower soil organic contents, the use of mechanical harvesting, and early stubbles in USSC. Stubble age did not significantly affect occurrence in Okeelanta fields. (Organic content and harvest method could not be evaluated at Okeelanta.) These findings suggest the potential for control strategies utilizing manipulation of field harvesting and husbandry practices, without the problems associated with the registration of a toxicant for infield use. Experimental studies are required to determine the efficacy of these strategies in reducing water rat occurrence and damage to sugarcane. Mechanical harvesting or trash disposal in hand harvested fields may reduce the occurrence of water rats in fields and restrict their geographical distribution. More adequate weed and grass control practices would also reduce field cover and food, and possibly decrease the soil's ability to support burrow systems. Implementation of any control effort could be restricted to only the potential problem areas of high soil organic content and older stubble fields.

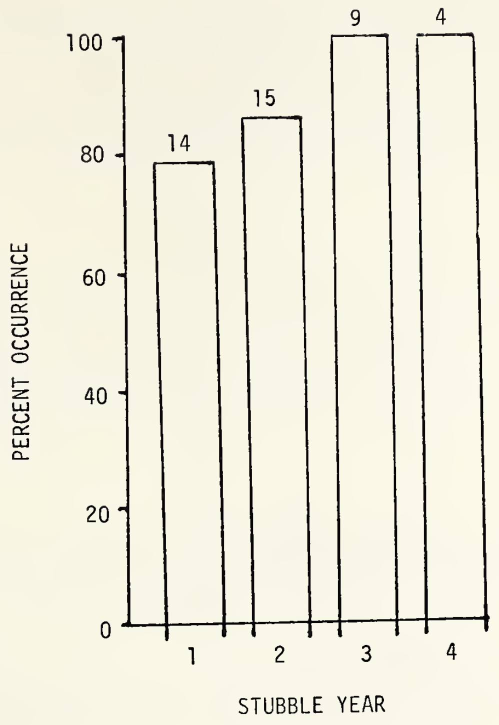

Figure 3. Percentage occurrence of Florida water rats by stubble year in fields at Okeelanta after the 1975-76 harvest season. Numbers at the top of each column represent sample sizes.

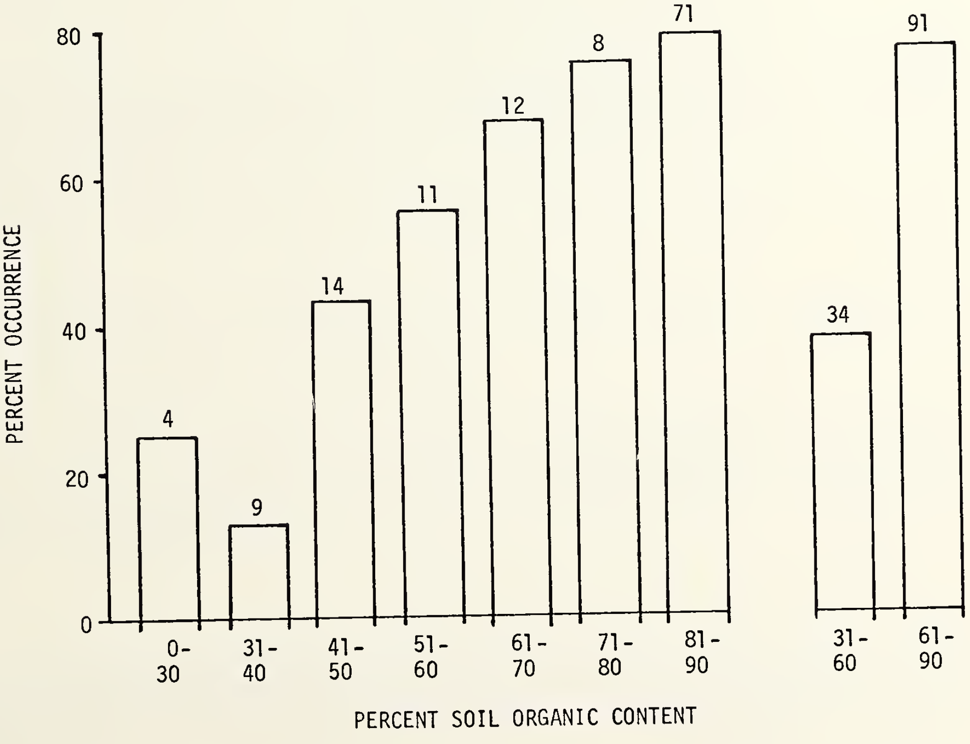

Figure 4. Percentage occurrence of Florida water rats in old stubble (second stubble and older) fields by percent soil organic content in the region of USSC with a high rate of occurrence of Florida water rats after the 1975-76 harvest season. Numbers at the top of each column represent sample sizes.

Table 2. Comparisons of field characteristics between areas of high and low occurrence rates of Florida water rats on USSC during the 1975-76 harvest season.

Field Parameter	L-area (Low Occurrence Rate) n	L-area (Low Occurrence Rate) percent	H-area (High Occurrence Rate) n	H-area (High Occurrence Rate) percent
Harvest method[a]				
Hand	13	17.8	110	67.5
Machine	60	82.2	53	32.5
Stubble Age				
First	11	15.1	33	20.4
Second and older	62	84.9	129	79.6
Percent Soil Organic Content[a]				
0 - 30 %	27	36.5	4	2.4
31 - 60 %	29	39.2	36	21.3
61 - 90 %	18	24.3	129	76.3

[a] Significant ($P < 0.001$) differences between L-area and H-area.

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ADVANCEMENT OF NEW BASIC SUGARCANE BREEDING LINES[1]

P. H. Dunckelman
U.S. Sugarcane Field Laboratory
Agricultural Research, Science & Education Administration, USDA
Houma, Louisiana 70361

ABSTRACT

Attempts are underway at the U.S. Sugarcane Field Laboratory at Houma, Louisiana, to advance new breeding lines that are suitable for the selection of superior breeding stocks and/or commercial varieties. One hundred and fourteen bi-parental crosses were made during 1978 with the idea of combining into a composite the economic features of the commercial breeding stocks with the hardiness and disease and pest resistance of the wild canes and related genera. Over 440,000 viable true seeds were produced and 226,000 of these came from a line (*Saccharum spontaneum* L. US 56-15-8) that is already producing canes with commercial potential.

INTRODUCTION

Basic sugarcane breeding stocks, and some from other genera related to sugarcane, were combined in crosses with selected commercial breeding canes to produce the true seeds at the U.S. Sugarcane Field Laboratory, Houma, Louisiana, from which improved varieties of sugarcane are developed. Special emphasis was placed on the use of breeding canes (US varieties) under development from new lines involving the wild species *Saccharum spontaneum* L. and the most highly recommended commercial breeding canes from the most recent CP (Canal Point, FL) and L (Baton Rouge, LA) agronomic series. The object of these and similar basic crosses involving other *Saccharum* species and certain genera related to *Saccharum* (Table 1) is to combine the desired characteristics of diverse germplasm into a composite in as short a time as possible.

Sugarcane crosses were made for the first time in 1972 at this location. To circumvent unfavorable weather conditions and carry out the breeding work, greenhouse and photoperiod techniques are essential (2, 3, 4, 5). By manipulating basic and established sugarcane breeding stocks under natural and artificially controlled environments, it was possible once again to make special crosses that would otherwise have been impossible at Houma.

PARENTAL MATERIAL

Parental material used in current crosses included three clones of the genus *Ripidium*, two of *Sclerostachya*, one of *Erianthus*, one a hybrid of *Sclerostachya* X *Erianthus*, two *S. spontaneum* clones, two F_1 clones of *S. robustum* Brandes & Jeswiet ex Grassl, and several derivatives (F_1, BC_2, BC_3) of five *S. spontaneum* clones including Pasoeroean, SES 32B, SES 577, US 56-15-8 and US 61-2-1. Also used in crosses with the above and various other new lines were 21 interspecific (*S. officinarum* L. X *S. spontaneum* L. x *S. sinense* Roxb.) CP and L commercial breeding canes from older established lines, 14 commercial breeding canes from new lines (CP '77 numbers from the BC_3 generation of the US 56-15-8 line and from a *Sclerostachya* X *Erianthus* line) and 11 US breeding canes from new early-generation wild lines.

In all, 46 clones of diverse genetic composition were used as parents during the flowering period which lasted from late September to early December, 1978. These 46 clones were representative of the available germplasm for the season, as some of the same clones were replicated on the carts of the greenhouse and photoperiod rooms, as well as on the outdoor racks.

The choice of parental material for the 1978 crossing season was based on criteria described earlier (6, 7, 8, 9). With each succeeding generation of selected parent stocks, the genetic base to breed improved sugarcanes for the U.S. mainland is being broadened. The immediate goal is to develop newer and better parent canes and the ultimate goal is to use these parents in more crosses to develop hardier, higher yielding sugarcanes with greater resistance to diseases, unfavorable environmental conditions and the sugarcane borer *Diatraea saccharalis* Fabricius.

FLOWERING

For production of tassels early in the season, while the weather was still warm, 24 select breeding canes were subjected to artificial daylengths on the carts of the photoperiod house. Twelve of the canes were CP and L varieties from established breeding lines, 11 were canes assigned CP numbers from the *S. spontaneum* US 56-15-8 line, and one was an intergeneric hybrid (*Saccharum* X *Sclerostachya* X *Erianthus*).

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[1] A contribution from AR, SEA, USDA in cooperation with the Louisiana Agricultural Experiment Station.

From flowering data taken in previous years it was known that the 12 canes from the wild lines flowered from 2 to 3 weeks earlier than the commercial breeding canes with which they were to be crossed. Therefore, in order to synchronize the flowering of the two groups of canes, it was necessary to start photoperiod treatment of the commerical breeding canes at least 2 weeks in advance of the time of treatment given the wild-line canes. The photoperiod schedule used for both groups consisted of a declining daylength (1 min/day) for 60 days. Treatment of the commercial-line breeding canes was started on July 1, 1978, and lasted through August 29, 1978, while that for the wild canes began on July 15 and ended on September 14, 1978. Thereafter, some of the canes were left outdoors until in full bloom and others were brought into the greenhouse to hasten tassel emergence and promote male fertility. Of 680 stalks grown to maturity in can cultures placed on the photoperiod carts, practically 100% were induced to flower early in the season, and the commercial canes were made to flower simultaneouly with the wild-line canes.

Approximately 1000 stalks of different genetic stocks were grown to maturity on the carts of the tall crossing greenhouse, and while no count of flowering stalks was made, excellent flowering occurred in all available types of breeding material. As an added advantage, some of the early-flowering, early-generation, new-line derivatives of S. spontaneum clones flowered simultaneously with some of the later-flowering canes from the photoperiod carts. Furthermore, canes from both greenhouse and photoperiod carts flowered in unison with a few early-generation new-line breeding canes taken from the outdoor racks. However, canes on the outdoor racks did not flower well during 1978. This was due to three causes: 1) the weather turned cool early in the fall and stayed that way throughout the crossing season; 2) some of the canes that were moved from the racks and placed between rows of tall canes on the greenhouse carts were shaded out by the taller canes, causing abortion of emerging tassels in the cane brought in from the outside; and 3) limited greenhouse space could accomodate but few canes brought inside, even though all would probably have flowered had it been possible to afford greenhouse protection for the canes during the latter weeks of fall.

CROSSING AND TRUE SEED PRODUCTION

The techniques for making crosses, ripening the true seeds, drying the seeds, germ testing the seeds and storing the seeds have been described (1, 4). No notable changes in techniques of crossing and true seed production were made during the 1978-79 breeding season.

The season was marked by excellent flowering on the greenhouse and photoperiod carts, a situation which allowed for the making of many desired crosses and very good seed set in most of the bi-parental combinations. One hundred and fourteen such combinations were made; by germination test counts of 1-gram samples of fuzz (1), an estimated 445,090 viable true seeds were produced (Table 1). Seed set in interspecific sugarcane crosses, involving 563 female (male-sterile) tassels averaged an estimated 790 viable seeds per tassel. Seed set in intergeneric crosses with 91 female tassels had only 47 viable seeds per tassel.

The introduction of new genetic factors into Saccharum from the related genera Ripidium, Sclerostachya, and Erianthus was tried in 19 bi-parental crosses and over 4000 viable true seeds were produced. Two crosses were made for biomass studies with the vigorous S. spontaneum clones SES 84/58 and SES 602 in combination with commercial canes, and these produced an estimated 45,546 viable seeds. Wild lines involving various clones of S. spontaneum and S. robustum were advanced to higher levels of breeding in 93 crosses which accounted for the production of about 395,000 true seeds.

Of special interest, the promising S. spontaneum US 56-15-8 line was advanced from the BC_3 to the BC_4 generation in 50 crosses that gave an estimated 226,000 viable seeds. Since canes with high sucrose content and high resistance to mosaic are already being selected from BC_3 progenies of US 56-15-8, it is anticipated that more valuable canes will be selected from the BC_4 generation of this line in the near future. Other new lines are beginning to show greater promise as they are advanced to higher generations through the long-term process of crossing, selecting and recombining the genetic features of the "best with the best" from each succeeding generation. Tens of thousands of seedlings, first- and second-line selections, and selections advanced to larger replicated trials are now undergoing testing in field trials and some of these may be future varieties for commercial sugar production. Yet, much remains to be done in the way of striving to further improve breeding techniques, screening and use of the great complexity of germplasm now present in the World Collection of Sugarcane and Related Genera.

Table 1. Breeding lines under development at Houma, Louisiana, 1978 season.

New breeding line and generation	Number of crosses	Estimated number viable seeds
F_1 *Ripidium bengalense*	3	1,136
F_1 *Ripidium elephantinum*	1	100
F_1 *Ripidium giganteum*	2	498
F_1 *Sclerostachya fusca*	7	1,152
F_1 *Sclerostachya narenga*	1	0
S. spontaneum SES 602 x BC_3 *S. spont.* US 56-15-8	1	9,246
R. kanasharoi x *R. bengalense*	1	0
F_1 *S. spontaneum* 84/58	4	36,300
(F_1 *S. spont.* x F_1 *S. rob.*) x Commercial	1	2,835
(F_1 *S. spont.* x F_1 *S. rob.*) x BC_3 *S. spont.* US 56-15-8	1	1,701
BC_1 (*Scler.* x *Erianth.*) x BC_1 *S. spont* SES 32 B	1	230
BC_1 (*Scler.* x *Erianth.*) x BC_3 *S. spont.* US 56-15-8	1	528
BC_1 *S. robustum* NG 28-251	1	13,320
BC_1 *S. robustum* NG 57-208	13	55,198
BC_1 *S. spontaneum* SES 577	1	3,800
BC_1 *S. spontaneum* US 61-2-1	5	13,188
BC_1 (*Scler.* x *Erianth.*) x *Scler. narenga*	1	0
BC_1 (*Scler.* x *Erianth.*) x F_1 *S. spont.* US 61-2-1	1	500
BC_1 (*Scler.* x *Erianth.*) x BC_3 *S. spont.* US 56-15-8	1	0
BC_2 *S. spontaneum* US 56-15-8	4	29,462
BC_3 *S. spont.* US 56-15-8 x BC_3 *S. spont.* Pasoeroean	1	1,220
BC_3 *S. spont.* US 56-15-8 x BC_1 *S. spont.* US 56-15-8	4	3,272
BC_3 *S. spont.* US 56-15-8 x BC_3 *S. spont.* US 56-15-8	8	29,949
BC_4 *S. spontaneum* US 56-15-8	50	226,075
Totals	114	429,710
Number seedlings from germination counts		15,380
Grand total		445,090

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SCREENING FOR SUGARCANE SMUT RESISTANCE IN FLORIDA - THIRD REPORT

D. G. Holder
Geneticist, Research Department, United States Sugar Corp.
Clewiston, FL

Jack L. Dean
Plant Pathologist, Agricultural Research Science and Education Administration
U.S. Department of Agriculture, Canal Point, FL

ABSTRACT

The smut reaction of 895 varieties (or clones) was tested. Seedpieces were artificially inoculated and planted in the field. The varieties were rated 5 months after planting, ratooned, and rated again after 5 months. Of 38 commercial varieties in Florida, 26 rated resistant or intermediate; 12 rated susceptible. Twelve varieties grown in Louisiana rated resistant. Four syrup canes rated resistant or intermediate. Over all 895 varieties, 62% rated resistant or intermediate and 38% rated susceptible.

INTRODUCTION

Sugarcane smut, Ustilago scitaminea H. Syd. & P. Syd., was discovered in Florida in June, 1978 (1). The first tests to determine varietal reaction to smut began soon afterward in July, 1978, and were a cooperative effort of the Research Department, United States Sugar Corporation, Clewiston, Florida, and the USDA, SEA, AR, U.S. Sugarcane Field Station, Canal Point, Florida. Due to the newness of the disease in Florida and the great interest of cane producers, two preliminary reports of varietal reactions to the disease have been made (2,3). The second of these reports gave the final result for the plant cane phase. The current report presents final results of the ratoon phase for selected, important, commercial varieties. The amount of smut generally increased between the plant and ratoon crops or remained the same. Rarely, a variety was placed a grade lower in ratoon than it had been in plant cane, but this resulted from the fact that, in the Hawaiian system, more smut is tolerated for the same grade in ratoons (Table 1).

METHODS AND MATERIALS

The varietal ratings in this report were extracted from tests in which 895 varieties, or clones, were screened. Twenty pieces of seedcane per variety (minimum 3 buds/seedpiece) were immersed 5 minutes in a suspension of 5-10 million smut spores per ml of water and incubated overnight under high humidity at about 87° F before being planted in the field. Samples from the smut spore suspensions gave 40-48% spore germination on 3% water agar held at 88° F for 6 hours. The cane was planted in July and the percentage of infected stools was recorded in December (5 months). The cane was ratooned in early March, 1979, and percentage of infected stools was again recorded in late July (5 months). Grades were assigned to varieties according to a rating scheme developed in Hawaii (4) (Table 1).

Table 1. The Hawaiian smut rating scheme.

Stools Infected (%)		Smut	
Plant	Ratoon	Grade	Reaction
0- 3	0- 6	1	Resistant or tolerant
4- 6	7-12	2	
7- 9	13-16	3	"
10-12	17-20	4	"
13-25	21-30	5	Intermediate
26-35	31-40	6	Susceptible
36-50	41-60	7	"
51-75	61-80	8	"
79-100	81-100	9	"

RESULTS AND DISCUSSION

The grades of 38 varieties grown commercially in Florida are shown in Table 2. Most of the commercial varieties were tested in two separate trials that were conducted approximately concurrently. Twenty-six varieties rated resistant or intermediate and 12 rated susceptible. Varieties will be watched closely in commercial fields to determine the degree of production losses resulting from smut infection. The degree of resistance that a variety must possess to be grown economically in Florida has not yet been determined.

The disease has not been in Florida long enough to permit correlation of test results with field decline of varieties after smut infection.

Some varieties of interest in other cane-growing areas were screened. The grades of 12 varieties grown in Louisiana are shown in Table 3. Syrup canes of the southeastern United States were rated as follows: CP 29-116 and CP 36-111, grade 1; CP 52-48, grade 2; and CP 67-500, grade 5.

Table 2. Smut grades of 38 Florida varieties in the screening test.

Variety	Smut Grade
CL 41-191	4
CL 41-223	5
CL 49-200	8
CL 52-39	1
CL 54-312	1
CL 54-334	8
CL 54-336	8
CL 54-378	4
CL 54-405	5
CL 57-39	3
CL 58-37	6
CL 59-2	8
CL 59-172	8
CL 59-994	5
CL 59-1052	5
CL 59-1167	3
CL 59-1332	2
CL 61-5	7
CL 61-205	6
CL 61-620	1
CL 65-260	7
CL 65-279	7
CL 65-294	7
CL 68-575	4
CP 56-59	1
CP 57-603	6
CP 57-614	1
CP 59-50	1
CP 59-73	1
CP 62-374	1
CP 63-306	2
CP 63-588	1
CP 65-357	1
CP 68-1026	1
CP 68-1067	3
CP 69-1052	1
CP 70-1133	1
L 61-49	1

Table 3. Smut grades of 12 Louisiana varieties in the screening test.

Variety	Smut Grade
CP 48-103	1
CP 52-68	1
CP 65-357	1
CP 67-412	1
CP 70-321	1
CP 70-330	1
CP 72-356	1
CP 72-370	1
L 60-25	1
L 62-96	2
NCo 310	1
L 65-69	1

The 895 varieties screened represent commercial varieties, parental types, experimental varieties in varietal selection programs, and historical varieties. The frequencies of varieties in the resistant and intermediate grades were: grade 1, 27%; grade 2, 11%; grade 3, 7%; grade 4, 6%; and grade 5, 16%. About 38% were in the susceptible grades 6 to 9.

The data collected on the wide range of varieties in this tudy will be of much benefit to the varietal development programs of U.S. Sugar Corporation and of the USDA. For example, smut-resistant experimental varieties were identified and many have been advanced in the selection programs while many susceptible varieties have been eliminated. Also, the identity of smut resistant varieties has permitted a shift to resistant parents in the crossing programs. There should be adequate resistance for varietal development programs to make progress by using resistant parents to increase the frequency of resistance in the offspring (5) and by increasing the number of seedlings and subsequent selections to offset the number of varieties that will be lost due to smut susceptibility.

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FREQUENCY OF RUST SUSCEPTIBILITY IN THE SUGARCANE VARIETY DEVELOPMENT PROGRAM AT CANAL POINT

Peter Y. P. Tai, Jack L. Dean, and J. D. Miller
Sugarcane Field Station
USDA, Science and Educational Administration
Agricultural Research
Canal Point, FL

B. S. Gill
University of Florida
Agricultural Research and Education Center
Belle Glade, FL

ABSTRACT

A total of 1131 clones in the 1979 Stage II variety trial and 105 clones in the Stage III variety trials were rated for susceptibility to sugarcane rust (Puccinia melanocephala H. & P. Syd.). About 15% of the Stage II clones were infected by rust to some degree around May 21, 1979; 7 weeks later, this had increased to 34%. Ratings indicated that the frequency distribution of rust susceptibility skewed markedly toward high resistance. Progenies from a few parents produced most of the susceptible clones. The susceptible clones in Stage III were infected consistently in all 4 locations (Hatton Bros. Farm at Pahokee, University of Florida AREC at Belle Glade, Shawnee Farms at Clewiston, and Gulf & Western Food Products Company at Okeelanta) with varying severity.

INTRODUCTION

Sugarcane rust caused by Puccinia melanocephala H. & P. Syd. was first found at Canal Point, Florida, on March 23, 1979 (1). Its effect on cane production in Florida is still uncertain. The discovery of rust in Florida enables us to evaluate the clones in our breeding programs and to select sugarcane varieties for resistance to rust.

The occurrence of sugarcane rust in the Caribbean area has been discussed by Presley et al. (7), Koike et al. (4), and Liu (5). The history of this disease in the Western Hemisphere was reviewed by Seymour et al. (8). Varietal reaction to rust ranges from highly resistant to highly susceptible (2,5,7). Recent rust epiphytotics in Central America and in the Caribbean area are causing concern because B 4362, an important cultivar in these areas, is very susceptible to the disease. The pathogen has eliminated highly susceptible varieties in Australia, Fiji (3), and India (6). Egan and Ryan (3) suggest that maturing cane may be less susceptible than young cane.

The objective of this study was to determine the frequency of rust susceptibility in sugarcane clones of Stages II and III in the USDA sugarcane variety development programs at Canal Point.

MATERIALS AND METHODS

A total of 1131 clones of Stage II and 105 clones of Stage III (CP 77-series) was used for this study. Stage II clones were planted in October, 1978, in single two-row plots (4.97m x 3.05 m) on the Canal Point Station. Stage III clones were planted in November, 1978, at 4 locations: Hatton Bros. Farm at Pahokee, University of Florida AREC at Belle Glade, Shawnee Farms at Clewiston, and Gulf & Western Food Products Company at Okeelanta. Clones in Stage III were planted in two replications in 2-row plots (4.57 m x 3.05m). The rust epidemic had been in progress at least since March, 1979; natural infection was adequate to differentiate the degree of susceptibility among clones. The clones were rated on a scale from 0 to 4 as follows:

Rating 0:	Highly resistant - Cane leaves healthy and clean or with chlorotic or necrotic flecks only.
Rating 1:	Very resistant - Few, poorly developed pustules revealed only by close inspection.
Rating 2:	Resistant - Pustules more abundant and usually larger, but infection obviously too light to cause economic loss.
Rating 3:	Moderately susceptible - Pustules medium in size and distributed over entire leaves; approximately one-third of the fully grown leaves infected and diseased spots visible even on young fully grown leaves; few infected old leaves are dry and dead.
Rating 4:	Very susceptible - Pustules large and often united; more than half of the cane leaves covered with pustules with even the tips of young leaves infected; most infected leaves dry and dead.

Two separate ratings were made on Stage II clones; the first one was made on May 21, 1979, and the second on July 9, 1979. Stage III was rated only once around May 21.

RESULTS AND DISCUSSION

According to the first rating on rust susceptibility, approximately 15% of 1131 clones of Stage II were infected with rust in some degree. Nine percent were very resistant (Rating 1), 4% were moderately resistant (Rating 2), 1% were moderately susceptible (Rating 3), and less than 1% were highly susceptible (Rating 4). The frequency distribution (Figure 1) was skewed toward high resistance or immunity. The second rating indicated that the proportion of infected clones had reached about 34% in Stage II. The frequency distribution had shifted toward higher ratings (Figure 1). The percentage of clones receiving a 0 rating dropped from 85 at the first rating to 66; the percentage for each of ratings 1 through 4 more than doubled. These changes probably reflected mainly the general advancement of the rust epidemic. Some clones that rated 1 or 2 at the first rating were rated as 3 or 4 at the second rating (Tables 1 and 2). However, a few clones that rated 1 or higher in May rated 0 in July. This decreased rust intensity in some clones, in spite of the general advance of the epidemic, suggests that increased resistance came with increased maturity (3).

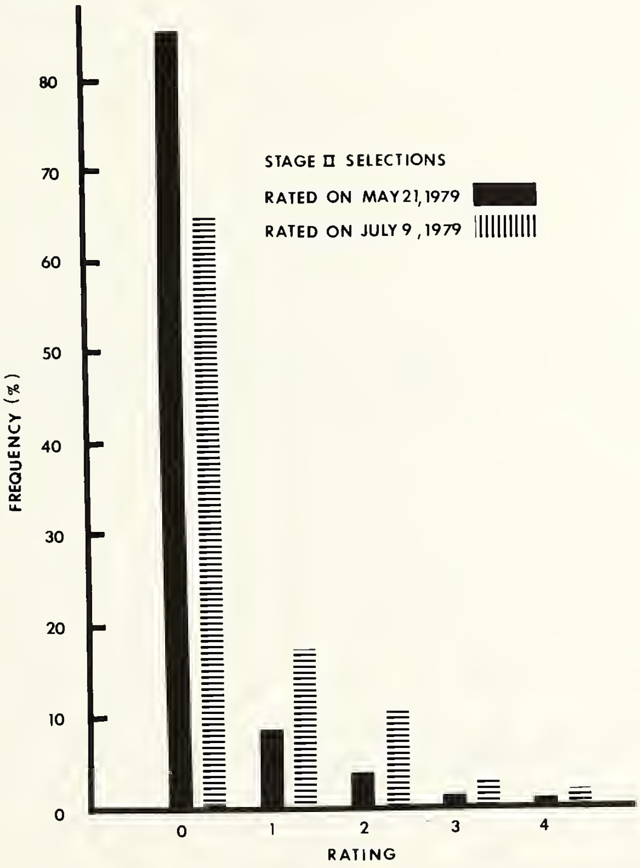

Figure 1. Frequency distribution of rust susceptibility from Stage II selections of sugarcane.

Stage II clones used for this study were genetically highly heterogeneous, being derived from 121 crosses involving 65 parents. Most clones that rated 3 or more at the first rating were produced from the 12 crosses, whereas the clones from all other crosses were more resistant (Table 1). In the second rating more than 60% of the clones rated 3 or more were from those 12 crosses (Table 2). Thus, the results

Table 1. Frequency of rust susceptibility in Stage II selections from several crosses, rated on May 21, 1979.

Cross	Total	Rating				
		0	1	2	3	4
CP 63-588 Polycross	113	101	9	2	1	0
CP 68-1026 Polycross	8	3	2	1	1	1
CP 69-1052 Polycross	44	37	3	4	0	0
CP 62-374 x CP 63-588	21	20	0	0	0	1
CP 62-374 x CP 69-1059	30	21	1	4	3	1
CP 62-374 x CP 70-1133	19	13	5	1	0	0
CP 65-357 x CP 68-1022	9	5	2	1	1	0
CP 65-357 x CP 68-1026	8	4	1	1	0	2
CP 65-357 x Cl 54-1910	5	2	0	1	2	0
CP 68-1154 x Cl 54-378	6	5	0	0	1	0
CP 68-1067 x CP 57-614	25	20	1	3	1	0
CP 68-1067 x CP 69-1056	26	21	5	0	0	0
CP 69-1062 x CP 66-1043	16	13	1	1	0	1
CP 70-1512 x CP 70-1133	38	23	8	4	1	2
CP 72-2079 x CP 73-343	6	2	2	1	1	0
Total of above	374	290	40	24	12	8
Total in test	1,131	964	102	45	12	8

Table 2. Frequency of rust susceptibility in Stage II selections from several crosses, rated on July 9, 1979.

Cross	Total	Rating				
		0	1	2	3	4
CP 63-588 Polycross	113	89	16	5	2	1
CP 68-1026 Polycross	8	2	1	3	0	2
CP 69-1052 Polycross	44	37	2	5	0	0
CP 62-374 x CP 63-588	21	13	5	2	0	1
CP 62-374 x CP 69-1059	30	17	4	4	3	2
CP 62-374 x CP 70-1133	19	15	1	1	2	0
CP 65-357 x CP 68-1022	9	2	3	3	0	1
CP 65-357 x CP 68-1026	8	2	1	2	1	2
CP 65-357 x Cl 54-1910	5	2	0	0	2	1
CP 68-1154 x Cl 54-378	6	3	1	0	1	1
CP 68-1067 x CP 57-614	25	16	3	1	2	3
CP 68-1067 x CP 69-1056	26	18	7	1	0	0
CP 69-1062 x CP 66-1043	16	6	6	2	1	1
CP 70-1512 x CP 70-1133	38	12	10	10	3	3
CP 72-2079 x CP 73-343	6	1	1	2	2	0
Total of above	374	235	61	41	19	18
Total in test	1,131	748	201	125	34	23

suggest that certain parents have produced most of the susceptible clones. Only a few parental clones were available for rating their rust susceptibility. Parental clones CP 63-588 and CP 65-357 rated 2 at the second rating, whereas no infection was detected on other parents (CP 62-374, CP 68-1067, CP 68-1026, CP 69-1052, CP 70-1133 and CP 70-1512). The sample size of most progenies in Stage II was small; therefore, the genetic behavior for rust susceptibility in sugarcane could not be firmly established with those data.

Rust ratings of CP 77-series clones at 4 Stage III locations are summarized in Table 3. Three locations, Hatton (7 clones), Shawnee (6 clones) and AREC (8 clones) had more clones rated as 3 and 4 than did Okeelanta (3 clones). The test at Okeelanta (11 infected clones) also showed fewer total infected clones than did the other 3 locations (Hatton = 41 clones; Shawnee = 29 clones; AREC = 28 clones). Thus, rust was less intense at Okeelanta than at the other three locations.

Although the spore population might be expected to vary among locations under natural conditions, susceptible clones were consistently infected with the pathogen even though their ratings might have varied from location to location. For instance, 5 varieties (CP 77-1014, CP 77-1067, CP 77-1231, CP 77-1446, and CP 77-1732) consistently showed higher ratings than other varieties in all 4 locations.

Table 3. Number of clones in each rust rating class at 4 Stage III locations, average rust rating at each location and number of infected plots at each location.[1/]

	Location			
Rust rating	AREC	SHAW	OKEE	Hatt
4	1	2	0	6
3	7	4	3	1
2	2	5	2	16
1	18	18	6	18
0	77	76	94	70
Average	0.31	0.35	0.19	0.47
No. of infected plots	36	43	12*	53

* One replication rated at Okeelanta, two replications rated at the other 3 locations.

[1/] Rating was made around May 21, 1979.

At present, the relationships among level of rust infection, cane yield, and juice quality are unknown.

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VIABILITY OF SUGARCANE SMUT SPORES IN A FLORIDA ORGANIC SOIL AT THREE MOISTURE LEVELS

Henry J. Andreis
First Assistant
Research Department
United States Sugar Corporation
Clewiston, Florida

INTRODUCTION

Sugarcane smut, caused by the fungus Ustilago scitaminea Syd., was observed for the first time in Florida on June 28, 1978 (1). Since a single smut whip has been estimated to produce as many as 5 billion spores (2) and thousands of whips were found in a single field of the sugarcane variety Cl 49-200, a possible build-up of viable spores in Florida organic soils was a matter of great concern. Fawcett (3) found experimentally that spores in a mineral soil die within a few months. Experiments carried out in India (4) showed that more than 70% of spores kept under dry conditions were still viable after 210 days; whereas, under moist soil conditions, almost all of the spores germinated within 48 hours. Waller (5) observed that germination of smut spores was frequently inhibited even in moist soils due to the presence of a fungistatic factor. He felt that the level of inhibition shown by the tested soils towards germination of smut spores was sufficient to enable an appreciable build-up of viable inoculum in moist soils in the absence of a cane crop. Information on longevity of sugarcane smut spores in organic soils at various moisture contents will be helpful in understanding the disease and possibly determining ways of reducing soil-borne infection.

MATERIALS AND METHODS

Spores were brushed from smut whips collected from a heavily infected field of sugarcane variety Cl 49-200. After removing most of the trash, the spores were dried at 25.5°C in a vacuum oven and stored in a desiccator for about 3 months prior to use. Spore counts indicated approximately 40 billion spores per gram of the stored material and germination tests indicated 79% viability.

A supply of Terra Ceia muck soil, a common organic soil in the Everglades, was collected from the top 6 inches of a field located east of Lake Okeechobee, an area where no smut has been observed in commercial cane fields. The soil was dried to about 16.5% moisture, and 1,600 grams were used for each treatment. Forty grams of spores were mixed with the soil for each treatment to give approximately 790 million viable spores per gram of soil. The soil-spore mixture was placed in 8-liter plastic containers after adjusting the soil moisture to 16.5, 60.9 and 129.9%. A control consisting of 16.5% moisture soil and no spores was also prepared. The 4 containers of soil were covered with plastic having a gauze center (to let in air) and were stored at about 25.5°C in the laboratory. Soil moisture was checked on a regular basis and water was added as needed.

Approximately 0.05 gram of the soil containing spores was placed in 10 cc of distilled water. After vigorous shaking, the suspension was allowed to sit for 30 minutes. The samples were again shaken and 0.5 cc of the suspension was drawn immediately and dispensed evenly on water agar plates. After incubating the plates at 33°C for 6 hours, germination counts were made.

Seedpieces of Cl 49-200 were obtained from a field east of Lake Okeechobee where no smut has been observed on this susceptible variety. The upper portions of the stalks were placed in plastic bags for 20 hours to enhance germination. An electric saw was used to minimize damage when cutting the cane into single-eye seedpieces. Young buds from the upper portion of the plant were selected since Byther and Steiner (6) found susceptibility increased from 5 to 80% in one variety between bottom and top buds. The single-eye seedpieces were soaked in tap water for 1 hour prior to inoculation. Holding the cut cane in plastic bags and immersing the seedpieces in water prior to inoculation were attempts to hasten germination, since rapid germination is a key factor in smut infection. The seedpieces were inoculated by dipping both ends in a soil-spore mixture, placing them in flats with buds up, rubbing a paste made from the same soil-spore mixture across the buds and covering with a sterilized organic soil. Flats of each treatment were then placed in an incubation chamber and held at 31°C for about 20 hours. The following day the flats were placed in a greenhouse and heavily watered. When the plants were 18-24 inches tall, they were transplanted in field plots 14 feet long at the rate of 8 plants per plot, each plant 2 feet apart. There were 4 replications for each of 6 inoculation dates. The 10-24, 10-26 and 10-31-78 inoculations were placed in the field on 11-28-78 and the 11-7, 11-21, and 12-19-78 inoculations were placed in the field on 12-21-78, 2-7-79 and 3-27-79, respectively.

Table 1. Soil temperatures at various depths.

Soil Depth (Inches)	°C[a]
1	27.8
2	26.9
3	25.9
4	25.3
5	24.9
6	24.6
Average	25.9

[a] Average of 10 locations in standing cane taken in October with air temperatures ranging from 27.8°C to 29.4°C.

Table 2. Field test results on smut spore viability after varying soil exposure times at three moisture levels.

Soil Treatment		Soil Exposure Time						Infection[b]	
% Moisture	Spores[a]	Zero	2 da	1 wk	2 wk	4 wk	8 wk	Total	%
16.5	10^9/g	11	8	13	6	4	2	44 a[c]	23.0
60.0	10^9/g	16	2	9	5	2	0	34 ab	18.0
129.9	10^9/g	10	5	4	0	0	0	19 bc	10.0
16.5	none	1	0	1	0	0	0	2 c	1.0

[a] Spores were 79% viable at initiation of experiment.

[b] As of July 27, 1979.

[c] Totals followed by the same letter are not significantly different from each other at the .05 level based on the Duncan's multiple range test.

Table 3. Effects of soil exposure time at three soil moisture levels on spore germination.

		Soil Moisture %			
		16.5	60.9	129.9	16.5[a]
		Germination %			
Exposure Time	Date				
Zero	10-24-78	79.0	79.0	79.0	---
24 hr	10-25-78	—[b]	—[b]	39.0	---
48 hr	10-26-78	—[b]	—[b]	20.0	---
1 wk	10-31-78	72.5	70.8	few[c]	---
2 wk	11-7-78	66.7	40.7	few	---
4 wk	11-21-78	65.7	4.2	---	---
8 wk	12-19-78	62.0	few	---	---
14 wk	2-8-79	57.9	few	---	---
28 wk	5-16-79	44.0	---	---	---
33 wk	6-27-79	35.3	---	---	---
37 wk	7-26-79	19.0	---	---	---
43 wk	9-7-79	9.0	---	---	---
52 wk	10-24-79	few	---	---	---

[a] Control, no spores

[b] Not checked.

[c] Few per plate.

RESULTS AND DISCUSSION

Soil temperature data (Table 1) were collected in October when air temperatures ranged from 27.8°C to 29.4°C. Soil temperatures in standing cane, where the soil was shaded, ranged from 27.8°C in the top inch to 24.6°C at the 6-inch depth. The average for the top six inches of soil at 10 locations was 25.9°C. Based on this information, the soil-spore mixtures were stored in the laboratory where a relatively constant 25.5°C temperature was maintained.

The first smut whips were observed on 2-27-79 in the 10-24, 10-26 and 10-31-78 inoculations and all were in the 16.5% moisture soil-with-spores treatment. There were significantly more smut-infected stools in the 16.5% moisture treatment than in the 129.9% moisture treatment (Table 2). The percentage of stools infected was 23, 18 and 10 for the dry, intermediate and wet soil treatments, respectively. There were some viable spores in the dry soil after 8 weeks of spore exposure, since 2 stools were infected. No infected stools were observed after 4 weeks of spore exposure to intermediate and after 2 weeks of spore exposure to the wet soil. There were two infected stools in the control plots; however, since the controls involved were in the field for 8 months prior to whip emergence, and about 50 days are all that is required from infection to whip emergence, it is most likely that field infection occurred. At the conclusion of the field observations on 7-27-79, the 10-24, 10-26, and 10-31-78 inoculations had been in the field 8 months while 11-7, 11-21, and 12-19-78 inoculations had been in the field 7, 5.5 and 4.5 months, respectively. In numerous microscopic observations, no spores were seen in the control soil.

The smut spores used in this work were stored in a desiccator for 3 months and had a germination percentage of 79 at the start of the trial (Table 3). After 1, 2, 7, 14 and 28 days of exposure to an organic soil containing 129.9% moisture, spore germination dropped to 39%, 20%, few per plate, few per plate, and none respectively. Spores exposed to 60.9% moisture soil had no viable spores after 14 weeks. Only a few germinated spores per plate were observed after approximately 1 year of exposure to the 16.5% moisture organic soil.

The spore counts agreed quite well with the field results, since no infected plants were observed when the number of germinated spores dropped to only a few per plate. If additional information concerning the effect of soil on spore viability is desired, only spore germination counts will be needed.

Based on the data presented, very few smut spores should remain viable in dry organic soil after 1 year, and most smut spores will remain viable less than 1 week in wet organic soil. Flooding a field or exposing the smut spores to moist soil by plowing would be ways of greatly reducing the number of viable smut spores in a given field. Under normal climatic conditions, viable smut spores should not continually build up in organic soils in Florida.

ACKNOWLEDGMENTS

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DE-FUZZING SUGARCANE SPIKELETS WITH A SAMPLE SEED SCARIFIER[1]

R. D. Breaux
U.S. Sugarcane Field Laboratory
Science and Education Administration, USDA
Houma, Louisiana 70361

ABSTRACT

The whorl of long bristles that surrounds each sugarcane spikelet gives the sugarcane inflorescence a silky appearance and true seed of sugarcane a fuzzy appearance. When seed viability is less than 50 seed per gram, a thick mat of fuzz must be sown to obtain an adequate plant population per flat in the greenhouse. Seedlings have great difficulty growing through the thick fuzz mat; control of fungi and bacteria is difficult and many seedlings die when the mat dries between waterings. A small seed scarifier used at Houma removed callus hairs quicker and easier than any previously reported method. There was only a moderate loss in germination of seed in thinly sown flats and a net gain in germination of seed of low viability in thickly sown flats.

INTRODUCTION

Each spikelet in the sugarcane inflorescence is surrounded at the base by a ring of long hairs that give the inflorescence and "true seed" a silky, fuzzy appearance. A rapid technique for de-fuzzing sugarcane seed offers two major advantages to the seedling program at the USDA Sugarcane Field Laboratory, Houma, Louisiana. First, it increases greenhouse utilization by allowing the sowing of seed from crosses with low seed viability in adequate quantity per flat to give an optimum number of seedlings. Second, the control of fungi and bacteria is easier without than with fuzz. This could be important if sugarcane smut, which threatens the U.S. mainland (2), were to enter Florida before Louisiana, as Florida is the source of seed for the Louisiana seedling program.

Attempts to de-fuzz sugarcane spikelets have been made with sulfuric acid, but the process is too dangerous to be used by unskilled personnel. Flame de-fuzzing, suggested by James and Miller (3), is often damaging to germination and the rug technique, suggested by da Silva (1) is too laborious. A sample seed scarifier was used to de-fuzz sugarcane seed and it is safer, quicker, and less damaging to germination than methods previously reported.

MATERIALS AND METHODS

Figure 1 shows the necessary equipment -- scarifier, screened funnel, and brush. The Forshag[2] sample seed scarifier is powered by a 1/3 hp electric motor. The inside wall of the drum is lined with a 40 grit aluminum oxide production cloth; the rotor that turns at 1725 revolutions per minute is steel.

Spikelets are de-fuzzed in the scarifier as follows: a 12 to 15 g sample of fuzz is placed loosely in the drum and the scarifier is turned on for 45 seconds. The machine pulls out the long callus hairs and rolls or balls them up. The tufts of hairs are separated from the spikelets by brushing the sample lightly for a few minutes over a 0.3 cm sieve or hardware cloth. The spikelets pass through sieve and funnel into a suitable container.

In two greenhouse experiments, the effect of the de-fuzzing process on germination was measured. In the first experiment, fuzzed and de-fuzzed spikelets of 7 bi-parental crosses were sown at the rate of 7.5 g (initial fuzz weight) per seedling flat measuring 35 cm x 50 cm. Preliminary germination tests on 2 g samples indicated that these 7 crosses ranged in viability from 3 to 120 viable seed per gram of fuzz. Fuzz mats in the control were thin ($0.004\ g/cm^2$) in this experiment.

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[1] A contribution from FR, SEA, USDA in cooperation with the Louisiana Agricultural Station.

[2] Distributed by the Seedburo Equipment Co., 1022 W. Jackson Blvd., Chicago, Ill. 60607. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

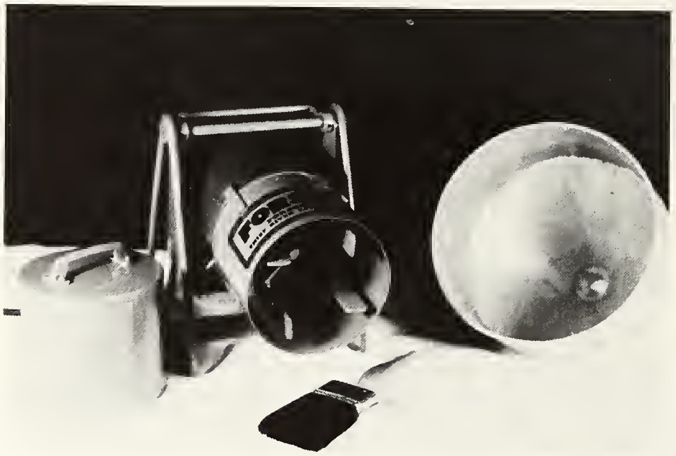

Fig. 1. Scarifier funnel with screen and brush used to de-fuzz sugarcane spikelets.

In the second experiment, fuzzed and de-fuzzed seed of 24 bi-parental crosses were sown at a fourfold rate, i.e., 7.5 g (initial fuzz weight) per one-quarter seedling flat. Preliminary germination tests indicated that fuzz of these 24 crosses all had relatively low viability, ranging from 1-27 viable seed per gram. Fuzz mats in this experiment were much thicker (0.017 g/cm^2).

In both experiments the final seedling count was made 3 weeks after seeding by removal of seedlings individually from each flat. The data were analysed statistically as paired comparisons of the germination of fuzz and de-fuzzed seed in each experiment.

RESULTS AND DISCUSSION

Figure 2 shows the relative quantities of untreated fuzzed seed (upper left), de-fuzzed spikelets mixed with tufts of hairs just as it comes from the scarifier (upper right), and the final de-fuzzed spikelets after sieving (center). The reduction in volume of fuzz after scarification and screening is over 60%. De-fuzzed spikelets establish better contact with the soil surface and uniform moisture is easier to maintain. Seedlings also germinate and become established quicker and with less difficulty than in thick mats of fuzz.

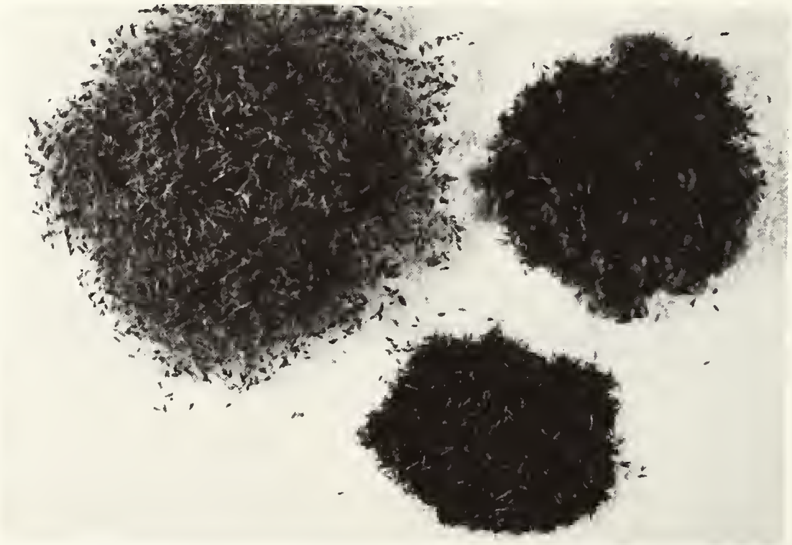

Fig. 2. The untreated fuzz (upper left), the de-fuzzed spikelets mixed with tufts of fuzz (upper right), and the final de-fuzzed spikelets after screening (center) from an equal initial weight of seed.

There was a significant difference in germination of seed from fuzzed and from de-fuzzed sugarcane spikelets when sown lightly in flats (Table 1). On the average de-fuzzed samples produced fewer seedlings (308 seedlings per cross) than fuzzed (334 seedlings per cross), indicating that some, but relatively little, damage or loss of seed occurred with the scarifier technique. The loss was greatest in crosses 500 and 501 that had relatively few viable seed; however, cross 504 with the fewest viable seed showed little loss.

Table 1. Germination of fuzzed and of de-fuzzed sugarcane seed in lightly sown flats (7.5 g/1750 cm^2).

Cross	No. seedlings germinated		t
No.	Fuzzed	De-fuzzed	value
500	40	26	
501	150	98	
503	195	160	
504	18	16	
505	441	369	
506	656	656	
525	840	833	
Av.	334	308	2.48*

* Significant at 5% level of P.

When the fuzzed and its paired de-fuzzed sample were sown more thickly, the germination of the de-fuzzed sample on the average was significantly greater (90 seedlings per cross) than that of the fuzzed (72 seedlings per cross). There was a positive response to de-fuzzing in germination of 22 of the 24 crosses, although the level of response varied greatly from cross to cross (Table 2).

Table 2. Germination of fuzzed and of de-fuzzed sugarcane seed from crosses with low seed viability in thickly sown flats (7.5 g/438 cm^2).

Cross	No. seedlings germinated		Cross	No. seedlings germinated		t
No.	Fuzzed	De-fuzzed	No.	Fuzzed	De-fuzzed	value
52	52	73	94	18	44	
54	94	104	96	101	112	
55	103	92	99	2	4	
56	185	203	101	178	240	
70	173	220	105	9	10	
71	150	175	106	6	23	
72	22	35	126	30	35	
73	68	65	138	84	96	
75	188	231	140	19	39	
77	14	19	143	16	20	
78	77	147	144	71	91	
87	40	41				
92	33	46	Av.	72	90	4.72**

** Significant at 1% level of P.

The results showed that the spikelets of these 31 crosses can be de-fuzzed in the scarifier with no more than a moderate loss in germination and that a net gain can be expected when fuzz would have to be sown thickly to obtain optimum populations in flats. At Houma, all fuzz with less than 50 viable seed per gram has been de-fuzzed before planting for the past 2 years. The procedure has resulted in better utilization of greenhouse space and increased seed germination.

SUMMARY

The sample seed scarifier de-fuzzed sugarcane seed more quickly than previously reported methods. Only a moderate reduction in germination occurred in the process, and germination was significantly improved when compared to fuzz sown in thick mats to obtain optimum seedling populations.

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YIELD RESPONSE OF THREE SUGARCANE VARIETIES TO CONTROLLED WATER TABLES[1]

Cade E. Carter
Agricultural Engineer, Baton Rouge, Louisiana

ABSTRACT

Cane and sugar yields of varieties CP 48-103, L62-96, and L 65-69 with the water table maintained two feet below the soil surface were not significantly different from yields with the water table maintained 4 feet below the soil surface in 1973, 1974, and 1975. Annual rainfall was above the normal 55 inches every year with 75.8, 59.7, and 67.8 inches occurring in 1973, 1974, and 1975, respectively. The experiment was conducted on 0.01-acre concrete bordered plots of silty clay loam soil on LSU's research farm near Baton Rouge, Louisiana.

INTRODUCTION

Since the mid-1920's the sugarcane industry in the United States has depended heavily upon the development of new varieties for survival. The potential for significant yield reduction due to sugarcane diseases, which severely crippled the U.S. industry in the early 1920's, has resulted in an elaborate sugarcane breeding and variety development program that is highly respected throughout the world. New varieties are released almost annually in the U.S. by cooperating industry, State, and Federal agencies, while old varieties are gradually phased out. The variety development program along with other practices has been responsible not only for commercial sugarcane varieties that tolerate diseases but also for increased sugarcane yield, sucrose content, and, consequently, sugar yields.

In 1967, studies were initiated in Baton Rouge, Louisiana, using 0.01-acre plots to determine if water management practices such as water table control, subsurface drainage, and irrigation could further increase cane and sugar yields (2). Results from these experiments were very encouraging with water table control and subsurface drainage increasing yields significantly (3, 4). Further experiments were conducted to determine design parameters for field drainage systems (1, 5). CP 55-30, a variety recommended by the American Sugarcane League, USDA, and LSU in 1967, was used in these experiments. Since then, new varieties have been released; consequently, CP 55-30 decreased in popularity and was dropped from the list of recommended varieties.

Since it was not known whether currently recommended sugarcane varieties would respond differently to water table control and drainage, an experiment was needed to determine the effect of water table control on the yield of several cane varieties. The objective in this experiment was to determine the differential yield response of three popular, recommended varieties of sugarcane to two constant water tables.

PROCEDURE

Three commercial varieties of sugarcane, CP 48-103, L 62-96, and L 65-69, were planted in the fall of 1972 in 12 concrete-bordered field plots, 0.01-acre in size, on Mhoon silty clay loam soil on LSU's Ben Hur Research Farm near Baton Rouge, Louisiana. The plot borders began one foot below the soil surface and continued downward 4.5 feet. Inside each plot, two tile drain lines were installed 5 feet deep and 9 feet apart. These drain lines were connected by pipe to a water level control sump outside the plot area. Each sump was equipped with a water supply, a water level control valve, and a drain so that the water in both the sump and the plot could be maintained at any level from the soil surface to 5 feet below it.

In April, 1973, after a good stand of cane was assured, treatments of constant water table levels 2 and 4 feet below the soil surface (measured half-way between top of ridge and bottom of furrow) were imposed on the plots with each treatment replicated twice for each variety. Water table levels in the plots were maintained continuously (during both growing and dormant seasons), until the experiment was completed. A check plot for each variety where the water table was allowed to fluctuate naturally was located on the same soil type as the controlled water table plots but about 350 feet away. These check plots, which had no concrete borders or drain lines, and thus, no water table control, received the same seeding, fertilizer, and pesticide rates and the same type and number of cultivations as did the controlled water table treatments, but they were not replicated.

Conventional planting and cultivating practices were followed using 12-inch high, bedded rows spaced 6 feet apart. Small diameter cased wells installed on the center row in each plot were used to measure the water table depth three times each week. The water level in the water control sump was adjusted as needed to insure the proper water table level in the plots. The plant, first ratoon, and second ratoon crops were harvested in November of 1973, 1974, and 1975, respectively. Yield, plant population, and stalk weight were determined by weighing and counting all stalks in each plot. Ten cane stalks from each plot were collected and used to determine juice quality in the laboratory which in turn, was used to determine sugar yields.

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[1] A contribution from the Southern Region, SEA, FR, USDA in cooperation with the Louisiana Agricultural Experiment Station.

RESULTS

Cane and sugar yields for each of the three sugarcane varieties were similar for both the 2- and 4-foot water table treatments (Table 1). In 1973 and 1975, when rainfall was unusually high, yields from the 4-foot water table treatment tended to be higher than those from the 2-foot water table treatment, whereas, in 1974, when rainfall was somewhat lower, yields from the 2-foot water table treatment tended to yield higher (Tables 1 and 2). With relatively high deviation from the mean yields and only two replications for each treatment, yield differences attributed to water table treatment were not significant.

Table 1. Cane and sugar yields, 1973-1975.

Sugarcane Variety	Water Table Treatment (Ft)	Yields 1973 Cane (T/A)	Yields 1973 Sugar (T/A)	Yields 1974 Cane (T/A)	Yields 1974 Sugar (T/A)	Yields 1975 Cane (T/A)	Yields 1975 Sugar (T/A)	3-Year Average Cane (T/A)	3-Year Average Sugar (T/A)
CP 48-103	2	33.2a	3.47a	32.4a	3.66a	23.3a	2.94a	29.6	3.36
CP 48-103	4	33.4a	3.61a	31.9a	3.04a	27.8a	3.40a	31.0	3.35
CP 48-103	Check	22.7	2.49	27.3	2.93	25.0	2.60	25.0	2.67
L 62-96	2	30.1a	4.05a	29.9a	3.64a	22.8a	3.04a	27.6	3.58
L 62-96	4	31.0a	3.94a	26.7a	3.14a	25.1a	3.22a	27.6	3.43
L 62-96	Check	23.0	2.69	25.7	2.81	20.9	2.29	23.2	2.60
L 65-69	2	33.2a	3.27a	31.6a	3.50a	24.6a	2.72a	29.8	3.16
L 65-69	4	35.2a	3.41a	29.5a	2.74a	25.5a	3.08a	30.1	3.08
L 65-69	Check	30.1	2.89	31.4	2.74	20.3	2.34	27.3	2.66

Cane and sugar yields of each variety followed by the same letter each year are not significantly different at the 95% level of probability.

Table 2. Monthly and annual rainfall. Baton Rouge, Louisiana.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						Rainfall (inches)							
1973	3.6	2.8	11.8	10.4	4.4	3.0	4.5	5.8	11.1	2.5	8.0	7.9	75.8
1974	7.1	4.8	4.6	7.8	6.4	1.1	7.2	5.9	4.9	0.5	5.2	4.2	59.7
1975	8.6	1.2	4.3	8.2	9.0	6.2	10.6	9.6	2.3	1.3	3.1	3.4	67.8

Apparently the sugarcane roots adapted readily to the two constant water levels in the soil. After the last harvest, several trenches about 3 feet deep were excavated across the cane rows to observe root distribution. It was obvious that roots in the 2-foot water table plots had been restricted to the upper 2 feet of the soil profile, whereas in the 4-foot water table plots the roots grew deeper. In both treatments the major portion of the cane roots appeared to be in the upper 18 inches of the soil profile. No physical measurements of the roots were made.

Cane and sugar yields for the controlled water table treatments were considerably lower in 1975 for all varieties than those in the two preceeding years (Table 1). This may have been due to the natural yield decrease of sugarcane or to damage by hurricane Carmen in early September 1974. High winds during that storm uprooted much cane, particularly where the cane stalks were tall and heavily populated. This damage may have reduced the plant population and the yield of second ratoon (Tables 1 and 3).

Table 3. Plant population and stalk weights, 1973-1975.

Variety	Water Table Treatment (Ft)	Plant Populations and Stalk Weights						3-Year Average	
		1973		1974		1975			
		(PPA)*	(PPS)**	(PPA)	(PPS)	(PPA)	(PPS)	(PPA)	(PPS)
CP 48-103	2	34800	1.92	38200	1.70	31800	1.46	34933	1.69
CP 48-103	4	33100^{a}	2.02^{b}	40600^{a}	1.56^{b}	32650^{a}	1.70^{b}	35450	1.76
CP 48-103	Check	24800	1.83	32300	1.69	34300	1.46	30467	1.66
L 62-96	2	24250	2.48	29650	2.01	25100	1.82	26333	2.10
L 62-96	4	24350^{c}	2.56^{a}	27650^{b}	1.94^{a}	25000^{b}	2.00^{a}	25667	2.17
L 62-96	Check	20800	2.21	26500	1.94	24600	1.70	23967	1.95
L 65-69	2	29450	2.25	37000	1.71	30950	1.59	32467	1.85
L 65-69	4	29750^{b}	2.38^{ab}	35150^{a}	1.68^{b}	33250^{a}	1.53^{b}	32717	1.86
L 65-69	Check	30200	1.99	31600	1.99	26400	1.54	29400	1.84

* PPA = Plants per acre.
** PPS = Pounds per stalk.

Plant populations and stalk weights of each variety followed by the same letter each year are not significantly different at the 95% level of probability.

It is interesting to note that cane yields among varieties were similar each year yet plant population and stalk weight differed significantly (Table 3). By combining data from the 2- and 4-foot water table treatments, the plant population of L 62-96 was significantly lower than that of the other two varieties all 3 years, while the weight per stalk was significantly higher during 1974 and 1975. In 1973, the stalk weight for L 62-96 was significantly higher than CP 48-103 but equaled that of L 65-69.

Cane and sugar yields from the controlled water table treatments were, in most cases, higher than those from the check areas (Table 1). For varieties CP 48-103, L 62-96, and L 65-69, respectively, 3-year average cane yields from the controlled water table treatments were 21, 19, and 10 percent higher and sugar yields were 25, 35, and 17 percent higher than those from the check plots. These differences were not analyzed for significance since the check plots were not replicated.

The 3-year average yield differences between the controlled water table treatment and the check were smaller for variety L 65-69 than for the other two varieties primarily because of higher yields from the L 65-69 check. This indicates that variety L 65-69 may be more tolerant to a fluctuating water table than the other two varieties.

Water table data for one check plot in 1974 and 1975 is shown in Fig. 1. The water table fluctuation for the other two check plots were similar. The high, fluctuating water table is due primarily to excessive rainfall. During the period of this experiment rainfall was above average each year. Rainfall data (Table 2) show that the annual rainfall exceeded the 55-inch annual average by 21, 5, and 13 inches during 1973, 1974, and 1975, respectively. The estimated annual rainfall needed to meet the evapotranspiration demand at Baton Rouge, using Thornthwaite's Water Balance Method (6), is 40 inches. Therefore, rainfall exceeded the estimated water need by 36, 20, and 28 inches during 1973, 1974, and 1975, respectively.

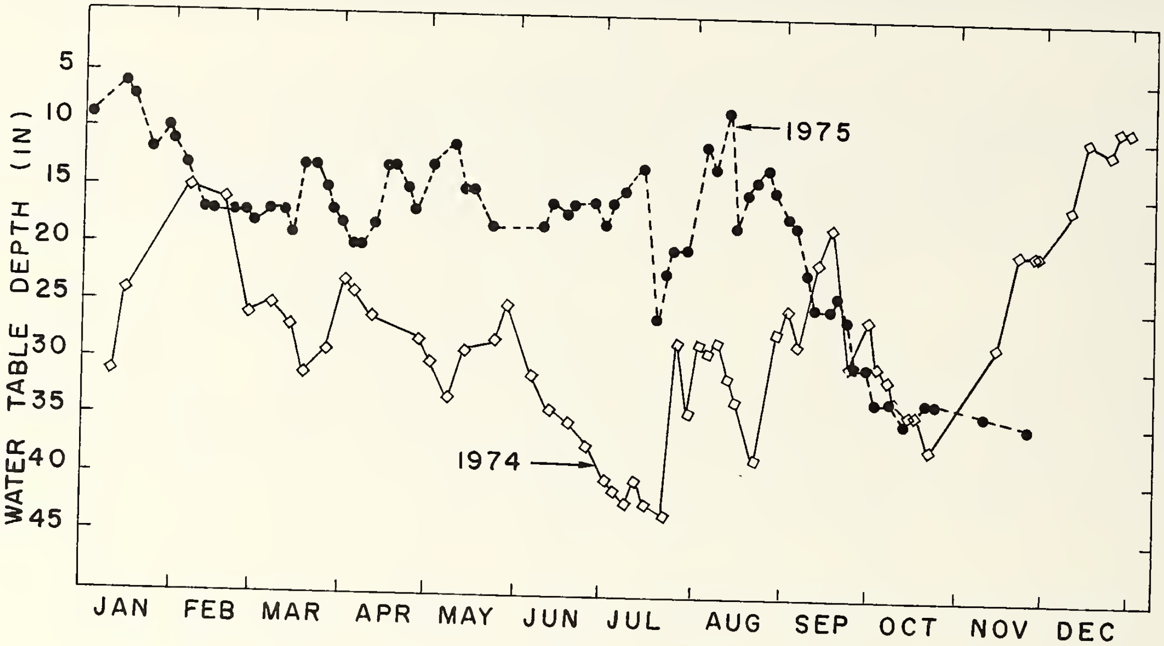

Figure 1. Water table depth below the soil surface in the L 62-96 variety check plot.

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THE EFFECT OF FERTILIZER POTASSIUM ON QUALITY OF JUICE AND YIELD FROM STUBBLE CANE OF EARLY MATURING VARIETIES

Laron E. Golden
Agronomy Dept., Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

ABSTRACT

Data were obtained at 10 locations during the four-year period, 1972-75, to determine the effect of fertilizer K on juice quality and yield from stubble cane of the early maturing varieties, CP 48-103, L 60-25, L 62-96, L 65-69 and CP 65-357. Selected for the study were soil types on which increases in yield of cane are normally associated positively with application of fertilizer K. At the first sampling, early in October, application of K resulted in average increases in sucrose content of normal juice, 0.58 percentage point, and purity, 2.09 percentage points. The increase in sugar per net ton of cane was 9.9 lb or was 6.3% higher than the check. Average net cane yields early in October were estimated by considering actual yields obtained at harvest late in November. Based on net cane and on sucrose and purity data, the increase in sugar yield due to K was 592 lb per acre at the first sampling, with 280 lb due to increase in net tons of cane and 312 lb to improvement in juice quality. At harvest, late in November, increases were obtained in sucrose, 0.32 percentage point, and purity, 1.00 percentage point, due to K. The increase in sugar per net ton of cane was 5.4 lb or was 2.7% higher than the check. The sugar yield increase due to K at harvest was 546 lb per acre. Of this amount, 359 lb were from increase in net cane and 187 lb from improvement in juice quality.

INTRODUCTION

The effect of fertilizer potassium (K) on juice quality has been reported by several workers (1,2,3,4,6,7).

From information obtained in 112 field experiments with sugarcane in Puerto Rico, Samuels and Landrau (6) found that use of K increased sucrose concentrations in cane only if cane yields were also increased.

Borden (1) noted in Hawaii that the highest yields of cane and sugar were generally from high nitrogen (N) and K fertilization rates. The best juice purities and sucrose yield percent cane were found from low N-high K treatments.

From work with a series of fertilizer x soil type x variety tests during a seven-year period in the Philippines, Tabayoyong (7) reported that sugar percent cane was not affected significantly by soil type or by fertilization.

A study conducted in Louisiana by Golden and Abdol (2) showed general improvement in juice quality due to fertilizer K by stubble cane of three early maturing varieties and a decrease in juice quality due to fertilizer K by CP 52-68. In plant cane, application of fertilizer K resulted in some juice quality improvement in early maturing varieties but none in CP 52-68.

The purpose of this study was to determine the effect of fertilizer K on quality of juice and yield from stubble cane of early maturing varieties.

MATERIALS AND METHODS

Sucrose, purity and yield data were obtained during 1972-75 from fertilizer tests with first and second stubble sugarcane grown at locations shown in Table 1. Early maturing varieties selected for the study were CP 48-103, L 60-25, L 62-96, L 65-69 and CP 65-357. The soil types selected were those on which applied fertilizer K has normally resulted in yield increases of cane (2,5). Plot size varied from 0.08 to 0.25 acre.

Table 1. Locations, varieties and soil types on which field tests were conducted.

Location number	Plantation	Year	Variety	Class(age) of cane	Soil type
1	Johnson	1972	L 62-96	First stubble	Commerce sil
2	Johnson	1973	L 62-96	Second stubble	Commerce sil
3	Evan Hall	1974	CP 48-103	First stubble	Commerce sil
4	Columbia	1974	CP 48-103	First stubble	Commerce sil
5	Oaklawn	1974	L 60-25	First stubble	Baldwin sil-Iberia c
6	Oaklawn	1974	L 62-96	First stubble	Baldwin sil-Iberia c
7	Oaklawn	1974	L 65-69	First stubble	Baldwin sil-Iberia c
8	Evan Hall	1975	CP 48-103	First stubble	Commerce sil
9	Columbia	1975	CP 48-103	Second stubble	Commerce sil
10	McLeod	1975	CP 65-357	First stubble	Commerce sil

Fertilizer N was applied at a constant rate of 160 or 240 lb per acre in each test. At each location, results from the check, or N-only treatment, were compared with the treatment which received K at the rate of 80 lb of K_2O per acre.

Samples, consisting of 20 stalks each, were obtained for juice quality determinations early in October and late in November from cane as it existed in the field prior to harvest. Yield data were obtained late in November after the second series of samples was obtained. Sugar yields per net ton of cane were calculated by use of a modification of the Winter-Carp formula.

Topsoil samples were obtained in the spring from check plots at each location.

RESULTS AND DISCUSSION

Table 1 contains information showing locations, varieties and soil types on which field tests were established. At locations 5, 6, and 7, three of the six replicates were on medium to heavy textured soils. Soils in the other replicates and at all other locations were light textured. Extractable K in all soils was medium low to low.

Data in Table 2 show the effect of fertilizer K on sucrose content and purity of juice samples and on yield from cane grown in each replicate at the 10 locations. Although some normal variation occurred among results from replicates within individual locations, increases in averages due to K at each location were relatively consistent.

Averages, increases over check, and statistical data for all locations are shown at the bottom of Table 2. Statistically, all increases over check were highly significant.

At the first sampling, it can be seen that application of K resulted in an increase in sucrose content of normal juice, 0.58 percentage point, and an increase in purity, 2.09 percentage points. The increase in sugar per net ton of cane was 9.9 lb or the increase over check was 6.3%.

Table 2. The effect of fertilizer K on sucrose content and purity of normal juice and on yield of sugarcane and sugar from stubble cane of early-maturing varieties.

	First sampling				At harvest							
									Yield			
Lcn. No.	Sucrose		Purity		Sucrose		Purity		Cane		Sugar	
	Ck	K	Ck	K	Ck	K	Ck	K	Ck	K	Ck	K
	- - - - - - - - - - - - - - - - % - - - - - - - - - - - - - - - -								Net tons/Acre		lb/Acre	
1	11.54	11.84	76.72	77.45	14.46	14.89	82.20	82.46	32.51	32.10	6739	6899
2	11.87	12.64	77.99	80.23	14.49	14.82	83.36	84.18	28.47	28.77	5912	6141
3	10.62	11.21	73.35	75.12	12.59	12.90	78.63	80.70	27.86	29.97	4980	5419
4	11.76	12.19	73.74	75.28	12.98	13.45	79.87	81.48	32.93	34.06	6006	6495
5	12.86	13.02	74.11	75.46	14.14	14.94	79.53	81.55	37.09	42.49	7666	9153
6	12.36	13.48	67.55	73.59	15.02	15.30	79.02	80.14	33.01	35.29	7280	7878
7	10.94	11.42	61.74	62.99	14.89	15.09	77.01	77.52	40.36	40.94	8610	8898
8	10.87	11.81	76.43	79.31	13.43	13.61	81.27	81.74	29.37	30.16	5578	5845
9	11.59	11.91	74.45	75.62	14.79	14.89	83.97	84.40	28.60	31.78	6090	6823
10	10.71	11.35	73.38	75.37	14.29	14.50	80.73	81.31	29.37	31.96	6005	6693
Ave.	11.51	12.09	72.95	75.04	14.12	14.44	80.55	81.55	31.96	33.75	6478	7024
Inc.over Ck.	-	.58	-	2.09	-	.32	-	1.00	-	1.79	-	546
LSD .01	-	.24	-	.86	-	.18	-	.57	-	1.08	-	265

At harvest, the increase in sucrose content of normal juice was 0.32 percentage point and the increase in purity was 1.00 percentage point. The increase in sugar was equivalent to 5.4 lb per net ton of cane or 2.7%.

The increases in yields due to K were 1.79 net tons of cane and 546 lb of sugar per acre, respectively. The increase in net tons of cane from the early maturing varieties studied was approximately equal to that obtained due to K applied in a large number of tests with stubble cane of the older, and generally medium to late maturing, commercial varieties in Louisiana (2,5). The effect of the 0.32 percentage point increase in sucrose and 1.00 percentage point increase in purity at harvest was equivalent to 187 lb of sugar per acre, or, of the 546 lb increase in sugar, 359 lb were due to increase in net tons of cane and 187 lb to increase in sucrose and purity.

Although yields were not obtained at the first sampling early in October, it may be assumed that the averages from check and K treatments were approximately 30.0 and 31.6 net tons per acre, respectively (2). Using this assumption, and juice data obtained at the first sampling, the increase in sugar yield due to K was 592 lb per acre at the first sampling, with 280 lb due to increase in net tons of cane and 312 lb to increase in sucrose and purity.

The data presented show that the total increase in sugar yield resulting from application of fertilizer K to the early maturing varieties studied was generally constant throughout October and November, but the portion of the increase attributable to improvement in juice quality was greater early than late in the harvest season.

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VARIATIONS OF NON-SUCROSE SOLIDS IN SUGARCANE, I. POTASSIUM [1/]

J. E. Irvine
U.S. Sugarcane Field Laboratory, FR, SEA, USDA
Houma, Louisiana 70361

ABSTRACT

Potassium is the most abundant mineral in sugarcane juice; processing concentrates potassium in the final molasses where high levels may inhibit the crystallization of sucrose. Crusher juice samples of sugarcane from replicated variety tests were assayed for K^+ by an ion-selective electrode. Despite large variation within tests, differences in K^+ content were statistically significant among the 7 varieties and 9 locations tested. Potassium concentration was lowest in the juice of CP 61-37 and highest in L 61-67; however, the range of differences among locations was 6 times that among varieties. Differences among locations may be due to fertilization practices or soil type. Juice from cane tops contained nearly twice the amount of K^+ as did stalks, but the concentration decreased in tops while it remained unchanged in stalks as the harvest season progressed.

INTRODUCTION

Recognized for millenia as a major constituent of plant ash, potash was the first inorganic chemical obtained from plants by early man through the simple technique of dripping water through a pot of ashes. That plants get potassium salts from the soil was shown by Liebig in 1840. While potassium ions are not used in the construction of cellular components, they are essential for cell division and elongation, and they are generally associated with sugar synthesis and translocation and with the production of starch.

In sugarcane, a potassium deficiency reduces growth, causes firing of older leaves, colors the upper surface of the leaf midrib red (4), and predisposes the plant to infection by some leaf diseases (7). While no description of toxicity symptoms is available, sugarcane will absorb potassium in amounts closely correlated with the amount available in the soil (5, 8, 11). Sugarcane from different soil types varies widely in potassium content (3, 5, 11); Texas cane generally is high in potassium (B. A. Smith, personal communication), Louisiana cane is intermediate (3), and Florida cane is low (3, 4). In Louisiana, cane grown on a clay soil was higher in potassium than that grown on a silt loam (5). Potassium is generally added as a fertilizer component (4, 5, 11, 12); yield responses to added potassium have been marked in Florida (4), varied in Puerto Rico (12) and slight in Louisiana (5).

In addition to increasing the yield of cane per acre, there is evidence that potassium used as a fertilizer causes an increase in sugar per ton of cane. Tests in Louisiana (5) occasionally give a statistically significant increase in sucrose in response to added potassium, and tests in Puerto Rico (12) show an increase in sucrose content only when there is also an increase in the yield of cane.

The distribution of potassium in the sugarcane plant is similar to that of plants in general, with the highest concentration in the youngest tissues (6). The top of the cane stalk has a higher potassium content than the base, and the leaf roll has the highest amount. Even a single leaf reflects this tendency, with the younger leaf base having more potassium than the older tip (10).

Early determinations of potassium in sugarcane showed that varietal differences were pronounced (3), and later studies (5, 12) confirmed this. A trend toward higher potassium in newer varieties was suggested (3) since, in Louisiana, the noble seedling D74 was higher in potassium than 4 other noble varieties grown at the time; the interspecific hybrids of the POJ series were higher still, and those of the Co and CP series were higher than the POJ's. This trend was especailly noticeable since soil potassium must have been reduced by continuous cropping without added K^+ during the transition from the noble varieties to the modern interspecific hybrids (3).

The data presented in this paper are the result of a study made to determine the variation in potassium in sugarcane as affected by variety, location and time of harvest.

[1/] A contribution from FR, SEA, USDA in cooperation with the Louisiana Agricultural Experiment Station.

MATERIALS AND METHODS

Samples were taken as part of the routine variety testing program from machine-harvested variety tests from 9 locations representative of the Louisiana sugarcane belt. Samples consisted of 15 stalks and were taken from 3 or 4 replications of 6 commercial and 1 experimental variety, in October and November of 1976. Crusher juice prepared from samples of cane from second ratoon tests was placed in self-sealing plastic bags and frozen for later analysis. Crusher juice was also taken from samples from first ratoon cane in the routine variety maturity test hand-harvested at our farm. These samples included five varieties (4 commerical and 1 experimental) and the cane samples were harvested every 2 weeks from October 3 to November 29, 1976. Millable stalks were separated from tops and each was ground separately.

Analyses for potassium ion concentration were done on raw, unfiltered juice. Samples were removed from the freezer and brought to 20 C in a warm-water bath. The melted juice was carefully mixed in the plastic bags and 100 ml aliquots were withdrawn and placed in a beaker with 2 ml of a saturated solution of sodium chloride to provide a constant ionic strength background. A specific ion electrode (Orion 90-01) was used to determine the concentration of potassium ions. This electrode is constructed so that potassium ions in solution can selectively create an electric potential in proportion to their concentration, and this potential is measured by a pH meter.

The data were subjected to statistical analysis by averaging the replicated data and using locations as replications to determine the mean square ratio (F value) for varieties and by using varieties as replications to determine the F value for locations.

RESULTS

The potassium ion concentration in the crusher juice of the 7 varieties from the multiple location variety trial ranged from 0.1291% in CP 61-37 to 0.1847% in L 61-67 (Table 1). Differences between varieties were highly significant and the difference between the variety extremes was 43% of the lower value. The average potassium content of samples from the 9 locations ranged from 0.0728% in Assumption Parish to 0.2039% in Avoyelles Parish, a three-fold difference. Differences among locations were highly significant but there was no clear association with soil type or geography. Fertilization practices at the individual locations were not determined.

Table 1. The potassium ion content of crusher juice of seven sugarcane varieties from nine locations in Louisiana.

(Average of 9 locations)		(Average of 7 varieties)	
Variety	% juice	Parish	% juice
CP 61-37	0.1291	Assumption	0.0728
L 62-96	0.1472	Lafourche	0.0881
CP 67-412	0.1591	Iberia I	0.1017
N Co 310	0.1603	St. James I	0.1058
CP 65-357	0.1673	St. Mary I	0.1367
L 65-69	0.1735	St. Mary II	0.1409
L 61-67	0.1847	Iberia II	0.1531
		St. James II	0.2259
		Avoyelles	0.2639
LSD (0.5)	0.0024	LSD (0.5)	0.0027

In the bi-weekly stalk samples taken from October 3 to November 29, there were, as an average of all harvest dates, significant differences among varieties (data not shown). However, there were not, as an average of all varieties, significant differences among harvest dates (Table 2), even though the extremes ranged from 0.1528% to 0.1914%. The tops, in contrast, showed significant differences among harvest dates, but not among varieties. A progressive decline in potassium content occurred throughout the harvest season.

Table 2. The potassium ion content of sugarcane on successive harvest dates, Houma, La. (average of 5 varieties).

Harvest date	Potassium % juice	
1976	Stalks	Tops
Oct. 3	0.1648	0.3240
Oct. 18	0.1528	0.3254
Nov. 1	0.1914	0.2638
Nov. 15	0.1545	0.2870
Nov. 29	0.1724	0.2511
LSD (0.5)	NS	0.0432

DISCUSSION

Three factors which might affect the potassium content at harvest were studied: location, variety and harvest date. Location effects were greatest and variety effects, though significant, were less. No effects were observed from harvest dates in stalk samples, although there was a decline in the potassium content of samples of cane tops as the harvest season progressed.

That location or soil effects are so marked is not surprising since sugarcane absorbs potassium in proportion to the amount supplied (8). The highly significant differences among varieties (Table 1) indicates genetic control over the uptake of potassium.

The economic impact of these differences is open to discussion. Fertilizer application of potassium is recommended for Florida and Louisiana for optimum yields. Potassium is often applied in Louisiana, even when no growth response is indicated, either for insurance against a possible deficiency, or in an attempt to enhance the sucrose content. While increases of up to 2 percentage points in sucrose % have been reported (12), responses in Louisiana have been slight, averaging about 0.38 percentage points (5). The profitability of applying fertilizer potassium for such marginal sucrose responses would depend on whether there is a concomitant tonnage increase and whether the variety response offsets the cost of application.

An even more important question is whether or not the potassium-induced increase in sucrose represents sucrose available to the mill. It is well established that inorganic constituents in cane juice have the effect of increasing the solubility of sucrose (9, p. 295), thus hindering molasses exhaustion and lowering sucrose recovery. The correlation (r = .81) between molasses exhaustion and ash percent non-sucrose solids is high (Thieme in 1). Potassium is the largest inorganic constituent of sugarcane juices, amounting to 30% to 50% of the ash (2, 3, 8, 9). It not only remains in the processing liquids, but also increases in relation to the other minerals as their concentration is reduced by clarification (2).

A simple demonstration of the effect of potassium on crystallization and recovery can be seen in Fig. 1. Solutions (75% w/w) of sucrose are placed in two containers, one with no additives and one with KCl added to equal the average (2) potassium content of Louisiana blackstrap molasses. After several days at room temperature, the saturated solution of pure sucrose had crystallized but the solution with added potassium had not.

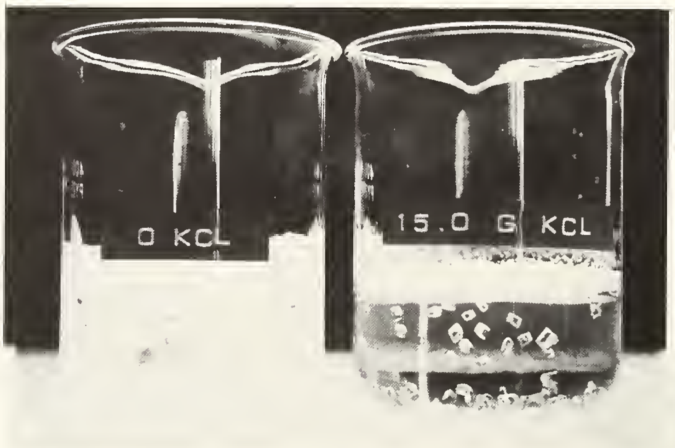

Fig. 1. Heavy crystallization after heating 150 g sucrose in 50 g water (left) and retarded crystallization of the same solution with 15 g KCl added.

Rather than increasing the recovery of sucrose, the use of potassium fertilizer in marginal cases could have the opposite effect. Minimizing excess potassium by variety selection and judicious fertilizer management may be an effective, low-cost method of improving molasses exhaustion. That improved exhaustion is possible is indicated by the normal range of final molasses purities from a high of 44% to a low of 26% in mainland cane factories. Molasses exhaustion depends on many factors, but decreasing ash by lowering potassium intake by the plant could accomplish a reduction in purity. Lowering the final molasses purity by only one percent would, at 13.5¢/lb raw value, represent a gain of about 10 cents per ton of cane, or $800,000/yr for the Louisiana industry alone. It remains to be determined what amount of potassium in raw juice would reduce the recovery of sucrose by one percentage point in the final molasses.

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PRELIMINARY INVESTIGATIONS ON THE EFFECT OF HARVESTING SYSTEMS ON FIELD LOSSES AND CANE QUALITY IN LOUISIANA[1]

B. L. Legendre
U. S. Sugarcane Field Laboratory
Science and Education Administration, USDA
Houma, Louisiana 70361

ABSTRACT

The harvesting performance of two production model cane combines was compared to that of whole-stalk cutters, the conventional method of harvesting cane in Louisiana, at five locations during the 1974 and 1976 harvest seasons. An average of 44% more cane as scrap was left in the field behind the whole-stalk harvester system. When scrap loss, trash content and cane quality are considered together, there was a 7.2% advantage in standard or paid tons per hectare in favor of the whole-stalk harvester system.

INTRODUCTION

Mechanical harvesting of sugarcane began in Louisiana on a commercial basis about 1938 (5). By 1947, approximately 50 percent of all cane was harvested by the whole-stalk harvester system. In this system a whole-stalk cutter cuts the cane at the ground and top and piles it on heap rows (7). From three to six rows are placed on each heap. This machine does not clean or strip the cane but leaves and adhering trash are burned after a few hours to one or more days on the heap row. After the cane is burned, it is loaded into tractor-drawn carts by a grab-type loader. The cane is hauled directly to the mill in the tractor wagons or loaded into trailer trucks for longer hauls. Although there have been numerous modifications to improve the performance, the basic design of the whole-stalk harvester system has remained virtually unchanged. As an alternative to the whole-stalk harvester system, several forms of combine harvesters have been developed locally; these were tried without success. These machines cut standing cane, burnt or unburnt, then chop, clean, and load the cane into tractor-drawn carts in one operation. In 1974 and 1976 two production-model combine harvesters were imported from Australia. This allowed for the direct comparison of the two systems of harvest under Louisiana conditions. This preliminary paper gives the results of five comparisons of the two systems on field loss and cane quality in Louisiana.

MATERIALS AND METHODS

On five occasions the performance of a production-model combine harvester was compared with the performance of the conventional Louisiana whole-stalk harvester system. Table 1 shows the type of harvest system, date and location of tests, cane variety and crop, and the land area involved in the tests.

Table 1. Cane variety and crop year, test date, test location and land area harvested for the five comparisons of the whole-stalk and combine harvester systems.

Test No.	Harvest system[1]	Cane variety & crop year[2]	Test date[3]	Test location	Land area (ha)
1	WS	CP 61-37 S	11/13/74	Raceland	1.8
	C	"	11/13/74	"	1.9
2	WS	CP 61-37 S	12/06/74	Raceland	2.1
	C	"	12/04/74	"	1.7
3	WS	CP 52-68 PC	12/19/74	Franklin	0.9
	C	"	12/17/74	"	1.0
4	WS	L 65-69 S	10/24/76	Brusly	1.5
	C	"	10/25/76	"	1.1
5	WS	CP 65-357 PC	12/05/76	Convent	1.2
	C	"	12/06/76	"	1.2

[1] WS represents whole-stalk, C represents combine.
[2] PC represents plant cane; S represents stubble.
[3] For the whole-stalk harvester system the date represents the day of cutting; for the combine system the date represents date of harvest.

In each of the five comparisons the cane to be harvested by the whole-stalk cutter was cut on the first day, burned on the heap row the second day, and hauled to the mill on either the second or third day after cutting. Concurrently, the cane to be harvested by the combine harvester was burned while standing in the field on the first day, then cut and hauled to the mill on the second day. For all five comparative studies the test fields were adjacent; the cane was of the same variety and age.

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[1] A contribution from USDA, SEA, AR in cooperation with the Louisiana Agricultural Experiment Station.

Field Losses: Field losses as scrap were measured immediately after harvest for the two systems. In each measurement from 8 to 10 plots (5.5 m wide by 11.0 m long) were chosen at random within each field. From each of these plots all merchantable cane was placed on a tarpaulin and weighed. Merchantable cane included whole stalks and stalk pieces not harvested during the normal operation, but no attempt was made to obtain stalk pieces from tops removed in the normal topping operation (10).

Cane Quality: Trash content and normal juice sucrose and purity were used as indices of cane quality. For each system of harvest the trash content was measured in the field. For the whole stalk harvester system, 8 to 10 samples of about 45 kg each were placed onto a tarpaulin by the grab-type loader and for the combine harvester system a like number of samples was removed from the top of the tractor-drawn cart by the grab-type loader. Actual weights were measured by a hydraulic load cell mounted on a custom loader (2). After the samples had been weighed, the stalks, pieces, and billets were stripped of all extraneous material (trash) and re-weighed. All trash was bagged and returned to the Houma Laboratory for separation into the components of tops, leaves, and soil. Trash content of each sample is reported as the percent total weight of trash relative to the gross weight of sample.

Samples for the measurement of normal juice sucrose and purity for the whole-stalk harvester system consisted of 15-stalk samples taken at random from each of 8 to 10 locations in the field. For the combine harvester system the equivalent weight in billets of a 15-stalk sample (approximately 14 kg) was taken for each of the 8 to 10 locations in the field. The juice analyses for the first three comparisons were made at the Houma Laboratory in the usual manner: Brix by hydrometer, apparent sucrose by polarization, and apparent purity as the ratio of apparent sucrose to Brix (8). Values for sample mill sucrose and purity were converted to the normal juice equivalent using factors supplied by those mills where the cane was milled. For the remaining two comparisons, juice quality data were obtained from the Audubon Sugar Institute (unpublished data).

Total gross tons of cane per hectare for each field was the sum of cane harvested per hectare plus the field losses measured as scrap. Undoubtedly, there were some undetermined losses of cane which occurred during cutting and harvesting by either system which are not accountable in this study. Trash content of scrap was assumed to be the same as that found in harvested cane. The conversion factor used to relate the total gross tons of cane in the field to standard tons delivered to the mill was derived from the following formula: C.F. = FNSP; where C.F. = conversion factor, F = field loss as the percent of total cane in the field, N = net cane as the percent of trash-free cane, S = standard sugarcane quality factor for percent of sucrose in normal juice, and P = standard sugarcane quality factor for percent purity of normal juice.

RESULTS AND DISCUSSION

Field Losses: Field losses as scrap for each system of harvest are shown in Table 2. Although considerable variation was noted in field losses from plot to plot and from field to field, it was observed that the condition of the cane at harvest influenced the amount of scrap left in the field by the harvest system. The more lodged the cane, the more scrap was left regardless of the system of harvest. Clayton et al. (1) noted similar results in Florida. In the final analysis for the present investigations, there was 44% more scrap left in the field behind the whole-stalk harvester system. Much of the scrap left in the field behind the whole-stalk harvester system, especially for the first two tests, was due to the poor adjustment of the basal cutting blade of the cutter itself. This resulted in stubble pieces of 10 to 30 cm long left uncut. However, scrap from the whole-stalk harvester system is recoverable at less cost than the scrap found behind the combine harvester system.

Table 2. Field loss of merchantable cane and trash content of harvested cane following harvest by the whole-stalk and combine harvester system.

Test no.	Field loss (MT/ha) systems of harvest		Trash content (%) systems of harvest	
	Whole-Stalk	Combine	Whole-stalk	Combine
1	25.5	9.3	13.4	11.6
2	16.1	10.6	9.0	7.7
3	8.0	4.8	3.6	7.6
4	3.2	4.4	7.3	15.3
5	3.5	2.5	9.3	16.1
Mean	11.3	6.3	8.5	11.7

Cane Quality: Trash content as a reflection of cane quality is shown in Table 2. The trash content varied considerably between and within tests; however, the cane harvested by the combine harvester system had an average of 27% more trash. As the trash content of cane increases above 10%, there is an associated reduction in the yield of recoverable sugar per ton of cane (6). Though the differences between harvesting systems in the amount of trash found in the cane were not significant, the average trash content was greater than 10% in cane harvested by the combine harvester system.

A separation of the trash into the three components of top, leaves, and soil showed that leafy trash comprised over 50% of the total trash regardless of the system of harvest. For the remaining two components a greater percentage of tops was found in the trash from the whole-stalk harvester system and a greater percentage of soil was found in the trash from the combine harvester system.

The trash undoubtedly had an adverse effect on normal juice sucrose and purity (Table 3). The observation that mechanical harvesting has resulted in higher trash and lower juice quality of cane in Louisiana, was first reported in 1948 (5). Similar conditions have occured in Florida as harvesting has shifted from manual to mechanical means (11). In fact, Zepp and Clayton noted that a percentage point increase in green trash reduced normal juice sucrose by 0.07 percentage points. More recently, Legendre and Irvine (6) found that a mixture of 60% green trash and 40% dry trash as 10% of the total weight of cane significantly reduced normal juice sucrose. In both studies there was a proportional reduction in normal juice purity which was also evident in the present investigations. Assuming that the above relationships reflect the true deleterious effects of trash upon normal juice sucrose and purity, the effect of either harvest system was an approximate 1.00 percentage point drop in normal juice sucrose and an approximate 3.00 percentage point drop in normal juice purity.

Table 3. Normal juice sucrose and purity of harvested cane for the whole-stalk and combine harvester systems.

Test no.	Juice quality (%) systems of harvest			
	Whole-stalk		Combine	
	Sucrose	Purity	Sucrose	Purity
1	12.1	74.0	10.2	68.7
2	13.2	79.7	11.5	76.7
3	13.3	74.4	13.0	75.6
4[1]	11.4	79.7	11.9	81.2
5[1]	11.8	78.4	11.2	79.8
Mean	12.4	77.2	11.6	76.4

[1] Unpublished data, Audubon Sugar Institute, Louisiana State University, Baton Rouge, Louisiana.

A possible cause of the lower normal juice sucrose and purity of the harvested cane from the combine system is the size of the billet. Irvine and Legendre (4) reported that cut-chopped billets deteriorate at a more rapid rate than do whole-stalks over time.

There was little difference between fields harvested by either the whole-stalk harvester or combine harvester systems, as an average of all comparisons, in the standing crop of cane per hectare (Table 4). Hodson (3), reporting on the same study, noted that there was an average 9.5 MT/ha more cane harvested by the combine harvester system. However, when considering scrap loss, trash content of harvested cane, and normal juice sucrose and purity conversion factors, there was a 4.8 MT/ha or 7.2% advantage in paid tons in favor of the whole-stalk harvester system (Table 4). In the Rio Grand Valley of Texas where the combine harvest system was compared with hand-cut, hand-topped, grab-loaded cane, Rozeff and Tucker (9) had reported that there was no difference in the yield of cane per hectare.

Table 4. Conversion of total cane in the field to paid tons delivered to the factory for the whole-stalk and combine harvester systems.

Test no.	Total cane in Field (MT/ha)		Paid tons delivered (MT/ha)[1]	
	Systems of harvest		Systems of harvest	
	Whole-stalk	Combine	Whole-stalk	Combine
1	83.4	85.6	49.8	48.6
2	97.0	111.6	83.2	89.5
3	71.9	58.7	67.6	53.7
4	67.0	76.6	59.8	61.0
5	85.3	74.9	71.1	54.5
Mean	80.9	81.5	66.3	61.5

[1] The conversion factor used to relate the total cane in the field to paid tons delivered to the factory considered scrap loss, trash content, and normal juice sucrose and purity conversion factors.

In summary, this preliminary comparison of the whole-stalk harvester system to two production-model combine harvester systems under Louisiana conditions showed three distinct advantages for the whole-stalk harvester system: 1) surge capacity, 2) economy of purchase and maintenance, and 3) recoverable scrap. More tests are necessary to study possible differences in scrap loss, trash content and the quality of the harvested cane between the two systems under the differing conditions found in Louisiana. Of special interest would be the recovery of paid tons of cane per hectare following sub-freezing temperatures or extremely lodged cane after a hurricane.

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THE EFFECT OF SMUT ON THE USDA SUGARCANE BREEDING PROGRAM AT CANAL POINT

J. D. Miller
USDA, SEA
Sugarcane Field Station
Canal Point, Florida

The need to screen for smut resistance adds a new dimension to the sugarcane variety development program at Canal Point and treatens to reduce its effectiveness unless the numbers of clones handled in the early selection stages are increased dramatically. The initial objective of the smut tests is to screen all of the clones in the breeding program for resistance to the particular race of the smut fungus that occurs in Florida. The smut test now operated cooperatively by the United States Sugar Corporation (USSC) at Clewiston and SEA-AR at Canal Point should provide information about the level of resistance or susceptibility of the commercial varieties and advanced selections of Florida sugarcane. The resistant clones that are adapted to Florida can be used extensively in making crosses for seed production for Florida during the 1979-80 crossing season.

The primary sources of tassels for the breeding program are 41 clones from Louisiana, 27 clones from Mississippi, and 40 clones from Florida. From 50 to 75% of their varieties were susceptible to smut in equivalent tests in Hawaii (1). If we used only resistant parental clones, we would reduce the total number of parents that could be used in crosses. Instead, for the 1978-79 crossing season, crosses in which both parents were known to be susceptible were eliminated. This means some crosses came from two smut-resistant parents, but most of the crosses made in the fall of 1978 probably had one susceptible parent.

The shift of varieties to obtain smut resistance means that by 1980 about 50% to 75% of the varieties in the crossing program will be different than those now in the program. These new varieties will represent a challenge, because their flowering response will be unknown. This response will influence the way these clones will be handled in the breeding program. They will be given a range of photoperiod treatments to insure that desired crosses can be made; this is an example of a relatively minor effect that testing for smut will have on the breeding program.

In current plans screening for smut resistance starts when varieties are advanced from Stage I to Stage II of our breeding program. Table I shows a basic outline of the breeding program and gives a rough average of the numbers of varieties in each selection stage. True seed is planted in the greenhouse in February, the seedlings are transplanted to the field in late April, and selections are made in October or November. A single stalk from a selected plant is planted in Stage I in a single-row plot 6 feet long. A year later selections from Stage I are assigned permanent CP numbers denoting the year and a selection number. Ten stalks from each selection are cut and planted in a Stage II plot (2 rows wide and 15 feet long). The same fall that a clone is advanced from Stage I to Stage II, it is also planted in a separate smut screening test. Data from the smut tests are considered when plants are selected to be advanced from Stage II to Stage III. Varieties in Stages III and IV are retested for smut resistance to insure that we have a true evaluation of each and that a susceptible variety is not released to the industry.

The effect of smut on the breeding program can best be illustrated by the data in Table I. In the past five years, we have tested between 50,000 and 60,000 seedlings (7 to 8 acres of land). With a 50% loss of plants due to smut we must double the numbers screened in all of the selection stages before the elimination of smut-susceptible clones to maintain the current selection pressure for other characters. Our goal is to increase the total number of seedlings from 60,000 to 120,000 (14 to 16 acres of land). The 8,000 to 9,000 varieties in Stage I (6 to 7 acres of land) should be increased to 16,000 to 18,000 varieties (12 to 14 acres of land). The 800 to 900 varieties (5 to 6 acres of land) in Stage II should be increased to 1600 to 1800 varieties (10 to 12 acres of land). The number of varieties in Stages III and IV can remain constant at about 105 and 8 to 12, respectively. Smut reaction can be determined from Stage II through Stage IV.

Table 1. The effect of smut screening on the test size of the different stages of sugarcane variety development program at Canal Point.

Stage of program	Test Size			
	Without smut screening		With smut screening	
	Numbers	Acres	Numbers	Acres
Seedlings	50,000 to 60,000	7 to 8	100,000 to 120,000	14 to 16
Stage I	8,000 to 9,000	6 to 7	16,000 to 18,000	12 to 14
Stage II	800 to 900	5 to 6	1,600 to 1,800	10 to 12
Stage III	105	1 per loc*	105	1 per loc*
Stage IV	8 to 12	1 per loc**	8 to 12	1 per loc**

* There are 4 off-station testing sites for Stage III.
** There are 8 off-station testing sites for Stage IV.

The smut testing program is a cooperative program with the Florida Sugar Cane League and SEA-AR. They are leasing land from USSC adjacent to the testing area cooperatively worked by USSC and SEA-AR. Most of the smut-susceptible varieties should be eliminated by the time varieties are advanced to Stage III, but we can continue to screen selections after that to make sure that we do not have escapes in the program. It is essential to increase the number of varieties in the early selection stages to have an adequate population size in the later stages so that the same selection pressure for desirable agronomic characters can continue to be applied.

Of the four varieties scheduled for possible release in the summer of 1979, one has taken smut under natural infection on the Beardsley farm. It is not known how many of these selections will contract smut in the inoculation tests. An additional problem is determining the degree of resistance a clone must have to be used as a commercial variety. This may take time to determine, and it involves the correlation of resistance ratings in inoculation tests with natural infection in the field.

The main drag on the breeding program is the increased work in handling large populations in the seedling stage, Stage I, and Stage II and from screening for smut in Stages II through IV. Dr. Jack Dean, Research Plant Pathologist with SEA-AR, is working on some techniques that may permit us to screen for smut in seedlings. It would be ideal if susceptible varieties could be eliminated in the seedling stage; then it would only be necessary to increase the size of the seedling stage. However, these techniques are not perfected; and, until they are, the numbers in these early stages must be increased to absorb losses to smut.

Recently released varieties from the breeding stations around the world are being collected at Canal Point. When these clones come to Canal Point, they will be included in a smut screening test and evaluated as commercial varieties. If a variety is adapted here, then it will be evaluated and released to growers. Our aim is to make successful varieties available to the Florida sugar industry regardless of where they were produced.

Foreign varieties have played a relatively small role in our breeding program, because many of them are tropical varieties that seldom flower under conditions in Florida. Most of them have been selected on mineral soils that are quite different from ours. When they are grown on the muck with its high nitrogen content, they do not mature but continue vegetative growth. As a result most of them produce excellent tonnage but have a very low sucrose content. Thus, the probability of finding a foreign variety that will be directly adapted for use as a commercial variety here is very slim.

In summary there will be three main changes in the variety development program. (1) The parental varieties that are currently being used in the crossing program must be changed to varieties that have smut resistance, (2) the size of the breeding program must be increased until smut-susceptible clones can be eliminated, (3) new techniques must be developed to permit screening for smut resistance at earlier stages in the breeding program.

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GENETIC BEHAVIOR OF SUCROSE CONTENT IN THE PARENTS AND PROGENY OF EIGHT BIPARENTAL SUGARCANE CROSSES[1]

C. A. Richard and M. T. Henderson[2]

ABSTRACT

The sucrose percentage for 100 clones from each of eight sugarcane crosses along with their parents was measured several times during 1971 through 1974. Significant differences in sucrose percent were found between the two parents for six of the eight crosses. Progeny sucrose values substantiate that sucrose content is a quantitative character as there were a large number of continuously distributed classes around the sucrose content of the parents of each cross. However, unlike typical quantitative characters, the progenies of the eight crosses did not fit a normal curve and the modal class was below the average sucrose of the two parents of each cross. An epistatic effect probably caused genes for low sucrose to express themselves among the segregates of all crosses. As an average of eight crosses, 25% of the progeny occurred outside the range of sucrose of the parents indicating transgressive segregation. Of this 25% only 2% occurred above the high sucrose parent. Crosses which had one or both parents with high sucrose produced the largest frequencies of high sucrose clones. The data indicate that selection for high sucrose clones should begin at as early a selection stage as possible in order to decrease the frequency of low sucrose clones in later stages.

INTRODUCTION

One of the major objectives in a sugarcane breeding program is high sucrose content. Current parental material in sugarcane offers a wide range in sucrose content and resulting progenies are highly variable. A study was conducted to determine the genetic behavior of sucrose content and the relative frequency of high sucrose segregates in each of eight crosses of the Louisiana breeding program in which the parents differed in sucrose content.

Venkatraman (6) studied the inheritance of juice quality and reported in 1927 that it was extremely variable even within crosses. He noted that in crossing two varieties, the sucrose of the hybrids was between the sucrose levels of the parents. Hebert and Henderson (3) in 1959 found that the brix of the progenies of different crosses varied according to the brix levels of the parents used. Antoni (1) reported in 1967 that seedlings produced from two parents with high sucrose or from one parent with high sucrose and another of low sucrose produced progenies with high sucrose. Also, he reported that seedlings from crosses of two low sucrose parents produced progenies with low sucrose content.

Mangelsdorf (4) in 1959 and Anzalone, et al. (2) in 1968 reported on the possibility of a physiological ceiling for sucrose percentage with the present genetic material.

MATERIALS AND METHODS

The unselected progenies of eight biparental crosses were used in this study. The crosses were chosen on the basis of known differences in sucrose content of the parental clones. The parentages of the eight crosses are shown in Table 1.

One hundred clones were chosen at random from the first stubble crop of single stools for each cross. Four stalks from each selected single stool were cut, hand cleaned, bundled, and assigned a clonal number. The four stalks of each single stool were used to establish a 10-foot clonal plot at the Louisiana Agricultural Experiment Station, St. Gabriel Farm, along with six replications of each of the parental varieties. Crosses 1 through 4 were cut and planted during the week of September 28 through October 2, 1970. Crosses 5 through 8 were cut and planted during the week of September 25 through September 28, 1972.

Samples from each clonal plot, including the parental varieties of crosses 1 through 4 were collected once in the plant cane crop in 1971, twice in the first stubble crop in 1972, and once in the second stubble crop in 1973. Samples from each clonal plot of crosses 5 through 8 were collected once in plant cane in 1973 and once in first stubble in 1974. For each harvest, juice quality determinations were made from a 10-stalk sample which was hand cut from each clonal plot and passed in a sample roller mill to give about 60% juice extraction. Pol readings were obtained from clarified juice samples and crusher juice sucrose was determined from Schmitz's table (5). The mean sucrose percent of all harvests for each clone was calculated as an average of all individual sucrose analyses from each clone.

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[1] The assistance of the American Sugar Cane League, members of the U.S. Sugarcane Field Laboratory, Houma, La., and the Louisiana Agricultural Experiment Station, Baton Rouge, La., made this research possible.

[2] Agronomist, American Sugar Cane League, and Professor of Agronomy, Agronomy Dept., Louisiana Agricultural Experiment Station, respectively.

RESULTS AND DISCUSSION

There were significant differences among the average sucrose percentages of the eleven varieties used as parents of the eight crosses (Table 1). Some of the varieties were known to be different in sucrose content and these values are in good agreement with previous data. In six of the eight crosses the two parents were significantly different in sucrose percent. It is evident comparing the progeny means to the parental means that the use of high sucrose parents resulted in high sucrose progeny means. The ranking of the average sucrose of the two parents for each of the eight crosses was almost identical to the ranking of the average sucrose of the entire progeny for each cross.

Table 1. Average sucrose percent for the parents and progeny of eight sugarcane crosses from 1971 through 1974.

		Sucrose Percent	
Cross #	Parents	Parental Means	Progeny Means
1	CP 52-68	13.29	12.90
	CP 48-103	13.57	
2	L 61-67	16.16	14.19
	CP 62-258	14.23	
3	CP 61-37	13.24	13.92
	L 62-96	15.69	
4	L 60-25	14.68	
	CP 57-614	16.05	14.23
HSD (.05)		.97	
5	CP 65-357	16.28	14.60
	CP 62-258	15.03	
6	L 60-25	15.38	13.92
	CP 66-346	14.23	
7	CP 52-68	13.35	13.18
	L 65-69	13.90	
8	CP 65-357	16.86	14.50
	L 65-69	14.96	
HSD (.05)		.97	

The mean sucrose of the entire progeny was lower than the mean sucrose of the high sucrose parent in all eight crosses and lower than the low sucrose parent for seven of the eight crosses. Only in cross 3, which had the lowest sucrose of all parents, was the progeny mean higher than the low sucrose parent.

The frequency distribution of the eight progenies, shown in Table 2, demonstrates the quantitative nature of sucrose content. There were a large number of classes and the segregates were continuously distributed in them. However, unlike typical quantitative traits, the progenies of the eight crosses were centered below the average of all parents.

The mean sucrose of the entire progeny fell below the sucrose value of the average of the two parents in all crosses by an average of 0.88% sucrose. As seen in Table 2, the mean sucrose of all parents fell in sucrose class 14.1 to 15.0% There were 74% of the segregates of the eight crosses (range of 60 to 85%) which had a mean sucrose value below that of the average sucrose of the parents of the eight crosses. There were 26% of the segregates of the eight crosses (range of 15 to 40%) which had a mean sucrose value above that of the average sucrose of the parents.

Table 2. Frequency distribution (%) for mean sucrose percent of the parents and progenies of the eight biparental sugarcane crosses.

	% Sucrose class centers										
Population	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	$\bar{x}$
Low sucrose parents						40.0	50.0	10.0			14.13
High sucrose parents						30.0		30.0	50.0		15.49
Progenies	.1	.8	2.0	5.7	15.6	25.6	26.6	16.2	6.7	.5	13.93

Note: The percentage figures for parents and progeny are not comparable. Total for high sucrose parents is 110%.

There were only 18% of the progenies of the eight crosses which had sucrose levels above the ranges of the high sucrose parent of the respective cross. This small percentage was found only in crosses 1 and 7 which had the lowest parental mean sucrose levels. In the other six crosses there were no segregates which had a sucrose level above the range of the high sucrose parent of the respective cross.

These results indicate the possibility of a multiple gene effect or epistasis. All clones, even high sucrose clones, apparently have a number of genes controlling sucrose level. Some of these genes are capable of producing high sucrose while others are not. The genes which do not enhance high sucrose development are often masked in their expression of this trait as in the case of a high sucrose clone. However, when two clones are crossed, these genes unfavorable for high sucrose development are able to express themselves among the segregates resulting in a smaller frequency of high sucrose segregates than expected.

The polygenic nature of the inheritance of juice quality has already been demonstrated and these data substantiate this fact. The presence of genes resulting in low sucrose in all clones limits the achievements possible in breeding for higher sucrose material. This would indicate that higher sucrose progeny could be obtained only with the aid of superior parent material and rigorous selection.

It was apparent that transgressive segregation occurred among the progenies of the crosses studied. There was a mean frequency of 25% of the progenies of the eight crosses (range of 8 to 44%) which had sucrose levels above or below the range of sucrose of the parents of the crosses. Table 2 shows that most transgressive segregates occurred below the range of the parents. In fact, 23% occurred below the range of the low sucrose parent of a cross, while an average of only 2% of the transgressive segregates occurred above the range of the high sucrose parent. This small percentage of high sucrose transgressive segregates was found only in crosses 1 and 7 which had the lowest sucrose parents and the lowest sucrose progeny.

Only a small number of the segregates of the eight progenies exceeded the highest sucrose variety used in the experiment and the largest frequency of clones fell below the high sucrose varieties. The possibility that sucrose is limited in its upper ranges has previously been mentioned, and these data indicate this to be true.

Estimates of the repeatability of sucrose on a clonal plot basis were obtained from correlation coefficients between the sucrose percent of the segregates of the eight progenies in each harvest and the average sucrose percent of all harvests. The average correlation coefficient for the eight crosses was .85** and suggests that the repeatability of sucrose on a clonal plot basis is moderately high. This indicates that selection for high sucrose clones in any one year would be at least moderately effective in obtaining clones high in sucrose as an average of several years.

SUMMARY

Louisiana sugarcane breeding programs rely on recurrent selection for continuous improvement in all traits, including sucrose content. The data have suggested that a multiple gene effect and transgressive segregation caused a large frequency of the progenies to be in a range of sucrose which is undesirable.

Because of the low percentage of really superior high sucrose clones, it is evident that only a small amount of improvement in sucrose percent over the level of the high sucrose parent can be expected in the progeny of a cross involving high or very high sucrose parents.

Many of the desired traits in sugarcane breeding, such as high sucrose, are quantitative in nature and are controlled by a polygene system utilizing complex physiological processes. Therefore, in simultaneous selection for these quantitative traits, there would be a rather small frequency of superior clones. This

indicates the need for large seedling populations in the breeding program as well as early screening for sucrose content to cull low sucrose segregates and increase the frequency of high sucrose segregates in later stages.

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THE USE OF RESIDUES FROM SUGARCANE FACTORY AND DISTILLERY FOR FERTILIZERS

George Samuels
Agricultural Research Associates
2001 Glenridge Way # 66
Winter Park, Florida 32792

ABSTRACT

Filter-press cake from the sugarcane factory and stillage or distillery slops from the sugarcane alcohol distillery have potential uses as sugarcane fertilizers, and should not be regarded merely as waste products. Filter-press cake, a dark-brown organic material, contains, on a dry-weight basis, about 40% organic matter, 2.2% N, 2.8% P_2O_5, 0.4% K_2O, and 3.1% CaO, as well as Mg, Mn, Fe and B. It has proven to be of value as a fertilizer, especially as related to P availability. In Brazil, it is applied below the seed for the plant crop at rates from 2 to 4 tons per acre on sandy soils with low cation-exchange capacity.

Stillage, a brown liquid, contains per 1,000 gallons 10 pounds N, 1 pound P_2O_5, 65 pounds K_2O, 30 pounds CaO, 8 pounds MgO, 53 pounds SO_4 and 530 pounds of organic matter if derived from molasses. When the cane juice is used for distillation, the stillage is much more dilute, with the K_2O dropping to 10 pounds per 1,000 gallons. The stillage is applied directly to the soil by means of tank truck or diluted in irrigation water.

The economics of handling these bulky materials for fertilizer usage has been a limiting factor in the past. At present, machines have been designed in Brazil to apply these materials efficiently and economically to the cane field, thus avoiding disposal problems in relation to environmental contamination. The use of the filter-press cake and stillage as fertilizer materials have allowed sugarcane farmers to reduce their purchase of chemical fertilizers to a minimum, except for supplementary N. The proper use of these materials related to soils, plant or ratoon crop, time of application, maturity and ash in juice are discusse

INTRODUCTION

The sugarcane factory and distillery in its task of producing sugar, molasses, and alcohol, also produce residual waste materials. The factory residues are primarily bagasse and filter-press cake; the distillery waste is stillage (also called slops or vinasse). The bagasse is burned as a fuel to provide energy for the factory or distillery. The filter-press cake and stillage are usually regarded as waste materials, often times requiring both effort and expense to dispose of in compliance with laws governing environmental protection. Yet, these residues contain plant nutrients (N, P, K, Ca, Mg) in sufficient quantities to be considered for use as fertilizers.

It is the purpose of this paper to summarize the experiments and commercial practices that are being used presently to convert these residues into fertilizers for sugarcane.

PHYSICAL AND CHEMICAL PROPERTIES OF RESIDUES

Filter-press cake

Filter-press cake consists principally of a mixture of sugarcane fibers, sucrose, coagulated colloids including cane wax, albuminoids, and phosphates of lime, plus soil. Most of the constituents come from the ground-up sugarcane. The lime is added in the process of neutralizing and clarifying the cane juice, and the soil enters as foreign matter clinging to the cane.

Physically, filter-press cake is a soft, spongy, lightweight amorphous dark-brown to black organic material. It can readily absorb large quantities of moisture when dry. It generally contains from 55 to 75% moisture on a wet basis when taken fresh from the rotary filters. Its volume-weight is low, being 0.375 on a dry-weight basis and about 0.57 at 65% moisture. In normal factory procedure 1,000 tons of ground cane will produce about ten tons of filter-press cake.

Filter-press cake varies somewhat in chemical composition, depending upon such factors as cane variety, the area where the cane is grown, the climate and mill performance. The range and mean values for the various chemical constituents of filter-press cake are given in Table 1. These values represent many samples taken from sugarcane mills from all of the cane-growing areas of Puerto Rico. Filter-press cake samples from Piracica, Brazil averaged in % dry weight 1.12 N, 2.77 P_2O_5, 0.34 K_2O, 5.20 CaO and 0.92 MgO.

The N occurs mainly as protein and in other complex forms rather than as the less complex ammonia or nitrate forms. However, conversion to these simpler forms proceeds very rapidly as the filter-press cake decomposes. Ramirez (5) showed that the peak of nitrate formation occurs about 5 months after it is applied to the soil. The P is present in the form of complex organic combinations such as phospholipids and nucleoproteins. Some P is also present as Ca phosphates which are formed when lime is added in the process of clarification. The organic P present in filter-press cake is less subject to fixation than inorganic sources supplying considerable available P for plant use.

The K content of filter-press cake is very low, less than 0.5% K_2O. The small quantity of K present is in a soluble, easily-leached form.

Stillage

Stillage is a brown liquid remaining from the distillation of the alcohol from sugarcane molasses or cane juice. It is relatively rich in organic matter which consists mostly of colloidal proteinaceous material from the yeast used in the fermentation operation as well as colloids from the cane juice itself.

The chemical composition of the stillage varies according to its source: molasses or cane juice (Table 2). The stillage derived from cane molasses fermentation has about six times a greater concentration of nutrient elements than that derived from a cane juice fermentation with the exception of phosphates which show little variation (Table 2).

The major plant nutrient constituent of stillage is K. Next highest is S in the molasses derived stillage. The CaO content is about half that of K_2O. The N content is relatively low and P is very low.

Stillage has lower percentages of plant nutrients than filter-press cake with the exception of K in the molasses derived stillage. The volume of stillage produced is very high. Grinding 1,000 tons of cane producing 6,000 gallons of molasses will give 41,000 gallons of stillage. The same 1,000 tons of cane using a direct juice fermentation for alcohol will produce 289,000 gallons of stillage.

FERTILIZER USAGE

Filter-press cake

Filter-press cake has been evaluated as a fertilizer for sugarcane (5,7) and other crops (4,6,7) for many years. It has been used successfully as a fertilizer source by cane laborers in their small vegetable plots. However, its large volume per unit weight and relatively low mineral nutrient content has limited its commercial usage as a fertilizer. Most mills either pile the material on unproductive fields near the mill or deposit in the river or ocean because of the lack of proper application equipment and the high cost of applying the bulky material.

Rising prices of commercial fertilizers and legal demands for proper disposal of filter-press cake without contamination of the environment have given new impetus to the use of this material as a fertilizer source.

Mechanization of the field application of filter-press cake has been achieved in Brazil. Filter-press cake applicators are in operation capable of carrying about 4 tons per load, applying it in the cane furrow before planting the seed. Other models consist of large trucks carrying up to 8 tons per load, also delivering the material in the furrow at the rate of about 2 tons per acre. At this rate, many Brazilian mills find their total filter-press cake productions for a grinding season is adequate for use in their plant cane acreage for that year. Responses to filter-press cake surface application in the ratoon crop is much less than for the plant cane placing the material below the cane seed.

Stillage

The use of stillage as a fertilizer source is relatively new with the majority of the work being done in the past four years in Brazil. This was necessitated by the large surplus of this residue from their gasohol program which could not be dumped into rivers or the ocean due to its environmental contamination. At present, stillage is applied by tank trucks and irrigation when used as a fertilizer. It is applied in the field to the ratoon crop after it is cut and before it resumes growth again.

There are two methods of truck application of stillage in the field: 1) Direct application by tank truck, which go from the stillage source to the field, equipped with spray systems operated by gravity, pump, or compressor, or 2) tank trucks delivering stillage to the field where it is pumped rapidly into a tractor-hauled tank trailer for infield application (9). A pump or compressed air operated tank truck covers up to 10 rows of cane per pass. The infield tank-truck trailer has an application width of 33 feet and distributes about 4,000 gallons in 4 minutes (2). Due to the corrosive nature of the stillage, the tanks are made of carbon steel or preferably stainless steel or fiberglass.

Table 1. The chemical composition and physical properties of filter-press cake, Puerto Rico 1952-55.

Constitutent	Number of Samples	Composition on a % dry-weight basis	
		Average	Range
N	43	2.19	1.07 - 3.13
P_2O_5	43	2.77	1.34 - 6.30
K_2O	41	.44	.02 - 1.77
CaO	42	3.05	.98 - 6.24
MgO	2	.49	.42 - .58
MnO_2	6	.17	.10 - .24
Fe_2O_3	6	1.05	.26 - 4.71
B_2O_3	4	.01	.00 - .02
Organic matter	1	39.5	
Sucrose	4	3	2 - 4
Moisture	18	61	56 - 69
Volume-Weight [1]	2	.375	.372 - .378

[1] cc/g

Table 2. The chemical composition, % wet basis, of sugarcane stillage [1]

Constitutent	Stillage drived from the fermentation of-	
	Molasses	Cane juice
N	.118	.028
P_2O_5	.015	.013
K_2O	.783	.122
CaO	.364	.069
MgO	.099	.021
SO_4	.640	.062
C	1.92	.059
Organic matter	6.34	1.95
pH	4.8	4.6

[1] Derived from (9).

Table 3. Acres per hour of stillage applied by various application systems as related to distance from distillery and source of stillage [1].

Stillage source	Gal./acre applied	Application system [2]	Area applied in acres/hr for delivery distance in miles		
			5	10	15
Molasses	3,600	1 or 2	.70	.38	.27
		3	4.00	2.25	1.50
Cane juice	16,000	1 or 2	.16	.09	.06
		3	1.00	.52	.35
Mixture of molasses and cane juice	6,400	1 or 2	.40	.22	.01
		3	2.32	1.30	.90

[1] Derived from data in (9).

[2] 1= tank truck (3,100 gal. capacity) from distillery into field using gravity flow or pump operation of sprayer.

2= tank truck as in system 1 with pressurized operation of tank.

3= tank truck (4,000 gal. capacity) from distillery to edge of field transferring to tractor drawn infield pump-operated sprayer (4,000 gal. capacity).

The acres per hour covered by the various distributors depend on the type of stillage used, distance from the distillery or stillage source and type of applicator. A general idea of the acres per hour covered by various stillage applicator equipment used in Brazil is given in Table 3.

The economics of the field application of stillage by tank truck is governed by many variables with the most important being the source of stillage and distance from the distillery to the field. Economic studies made by Copersucar (9) in Brazil showed that beyond a 6-mile radius of distillery to field, tank truck application of stillage derived from cane juice was not economical because of its high dilution, and mineral fertilizer usage was advisable. Brieger (2) cites an approximate cost of $13 per acre for applying 3,750 gallons of molasses-derived stillage with an average hauling distance of 6 miles from distillery to field. This operation was for a Brazilian mill-distillery complex producing daily 26,400 gallons of alcohol and 396,000 gallons of stillage and applying the stillage to 19,000 acres of ratoon fields in 180 days of operation. An increase of 20% in tons cane per acre was attributed to the stillage application as compared to the use of no commercial fertilizer giving a profit of $250 per acre.

Stillage distribution in Brazil by means of irrigation is limited, mostly because the majority of the cane is grown without irrigation. Some furrow and overhead irrigation is practiced for seed-cane plantations and commercial fields usually within a 3 mile radius of the distillery. Economic studies (9) showed that with cane juice-derived stillage, furrow irrigation up to a 6 mile distance was more economical than tank-truck application of the same stillage.

The stillage used for irrigation can be applied directly, especially if derived from the cane juice. However, dilution of the stillage is prefered, because the minimum amount of liquid needed to do an adequate job of irrigation would often mean elevated rates of K application if undiluted stillage is used. The dilution is up to 1:10 for molasses-derived stillage, mixing it, often times, with mill waste water. Where pipes are employed to handle stillage, either in moving it from the distillery to a pond or holding tank or for irrigation, they must be made of materials able to resist the corrosive action of the undiluted stillage. Plastics, fiberglass, and coated pipes are normally used.

DISCUSSION

Filter-press cake and stillage can be used as fertilizer sources for sugarcane. The low concentration of major fertilizer elements (N,P,K) makes it necessary to carefully consider the economics of transportation and application despite the fact that they cost nothing for their nutrient content. When proper consideration is given to the costs involved in disposal of the residual materials to avoid contamination of the environment, the economics of using these residual wastes as fertilizer sources becomes more favorable.

The merits of filter-press cake as a fertilizer goes beyond its actual N,P,K content. Being mostly organic it provides both increased moisture holding and cation-exchange capacity (CEC). In the predominantly light textured, low CEC cane soils of Brazil, the beneficial results of filter-press cake usage in increasing cane tonnage appears to be more than can be accounted for by mere fertilizer units present. Experiments (1) have shown increases in yields even when filter-press cake is used with N,P,K, fertilizers. In Puerto Rican soils with high CEC and no problems of moisture availability, the author obtained limited responses of increased cane tonnage to filter-press cake application up to 10 tons per acre. However, in an acid, low CEC Ultisol, tons of cane per acre was increased by 12% (7).

Filter-press cake is not a balanced fertilizer being low in K. To improve its nutrient balance and reduce transportation costs, compost mixtures of filter-press cake and stillage are being evaluated in Brazil. Bittencourt [1] at the Copersucar Technical Center, Piracicaba, Brazil, is adding stillage and also natural or thermophosphates to filter-press cake to increase its mineral content. The mixture is composted for 60 to 80 days to complete fermentation of the organic materials and reduce its moisture content. Representative analyses of the various compost mixtures are given in Table 4.

Stillage as a fertilizer material has limits as to the amount that can be applied per acre without producing detrimental effects in sugarcane production. Very high rates of stillage application, usually over 6,500 gallons per acre, can increase the ash in juice to levels which can cause problems in sugar crystallization and quality. Mill analyses in Brazil indicate increases in starch in the cane juice, but lower cane fiber content with large applications of stillage. This may be due in part to greater vegetative growth which delays the cane's normal maturity. In some cases, ripeners have been used to counteract this retarding of maturity.

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[1] Personal communication

The amounts of stillage to apply without causing problems in the ash in juice and delay in cane maturity is closely related to varieties and soils. Varieties show a differential response in accumulation of K and resulting high level of ash in juice (8). The lighter the soil texture, lower the CEC, and greater the internal drainage, the less chance for detrimental accumulation of bases in the soil due to stillage application.

If stillage is applied at rates equivalent to the K needs of the cane crop and the available K in the soil, there should not be any high levels of ash in the juice or serious delay in cane maturity. For the majority of Brazilian soils in the State of Sao Paulo, the use of 3,000 to 5,000 gallons per acre of molasses-derived stillage is adequate. Unfortunately, the problem with stillage usage is the large quantities that must be disposed of daily when the distilleries are making alcohol for gasohol. In the light texture and low CEC soils in Brazil, large applications do no apparent harm to soil fertility. Despite dumping of up to 100,000 gallons per acre in a 15 year period on a red-yellow sandy podzolic soil, the field was in cane production after a two year fallow. But soils with a high CEC and illitic or montmorillinitic clays can suffer imbalances due to high applications of stillage. Thus care will have to be used in stillage application for sugarcane in the organic soils of Florida, the poorly drained soils of Louisiana, and the heavy textured soils of Texas. Experiments are needed in the sugarcane areas of the United States and Puerto Rico to determine the maximum, as well as the economic rates of stillage application for various soils.

Research efforts in Brazil have been directed to the concentration of stillage in order to lower its transportation costs to the field. The research work (9) can be classified into two groups: distillery and using evaporation with external heat sources. The distillery could achieve concentration of the stillage by increasing the amount of alcohol in the fermentation mass before distillation, elimination of the dilution of stillage by condensed steam, and recirculation of stillage in the dilution of the molasses or pasturized cane juice. External or waste heat available from the distillery or mill could be used with evaporators to concentrate the stillage (3).

As sugarcane growers intensify their efforts to save energy, they must give serious consideration to the economic feasibility of using filter-press cake and stillage as fertilizer sources rather than as waste materials. These residues provide needed sources of N, P, K, Ca, Mg.

Table 4. Nutrient content, % dry weight of composted[1/] mixtures of filter-press cake with stillage and rock phosphate[2/].

	Composted mixtures of filter-press cake with-		
Nutrients	No addition	Stillage[3/]	Stillage + rock phosphate[4/]
N	1.12	2.21	1.22
P_2O_5(total)	1.71	1.99	8.18
P_2O_5(soluble in citric acid)	1.52	2.10	5.90
K_2O	.34	1.56	1.92
CaO	5.20	7.08	14.45
MgO	.92	.71	.85
Moisture	56.6	71.5	56.0

[1/] Composted for 80 days except for filter-press cake ± stillage which was sampled at 30 days.

[2/] Data derived from unpublished data of V. C. de Bittencourt, Coordinator of Soils and Fertilizers, CTAG, Copersucar Technical Center, Piracicaba, Brazil.

[3/] A mixture of approximately 1 gal. stillage with 11 lbs. of filter-press cake (68% H_2O).

[4/] Same mixture as 3/ plus 0.5 lbs. of natural rock phosphate.

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THE POTENTIAL OF LIQUID CHROMATOGRAPHY FOR THE ANALYSIS OF SUGARCANE

J. Wong-Chong and F. A. Martin 1/
Louisiana Agricultural Experiment Station

INTRODUCTION

Polarimetric analysis is the technique traditionally employed to determine the sucrose content of juice samples for the sugarcane industry. Although this technique is adequate under ideal conditions, it may have serious limitations under circumstances where optically-active substances other than sucrose are present (2). Under such circumstances more accurate methods of sucrose-analysis include enzymatic methods, gas-liquid chromatography with prior derivatization, paper chromatography and liquid chromatography. However, considerations of cost, time of analysis per sample and the complexities involved in these techniques have deferred the acceptance of these methods by sugarcane industries.

Recent developments in the area of pressurized liquid chromatography (HPLC) have made possible the rapid analysis of sugar mixtures with minimum sample preparation (3). The possibility of getting accurate estimates of sucrose, reducing sugars, and deterioration products in one analysis arouses ones interest. As a minimum, such technology would prove to be extremely useful for physiological research. The objective of the ensuing research, therefore, was to explore the possibility of using HPLC for the analysis of sugarcane saccharides.

THE BASICS OF CHROMATOGRAPHIC ANALYSIS

"Chromatography is a method of analysis in which the flow of a solvent or gas promotes the separation of substances by differential migration from a narrow initial zone in a porous sorptive medium" (1). There is a mobile phase in which the components of interest are carried and a stationary phase with which the components of interest interact. As the name implies, in liquid chromatography the mobile phase is a liquid This mobile liquid can range from polar to non-polar depending upon the separation to be accomplished.

In earlier liquid column chromatography the mobile liquid was carried through a vertical glass column by the force of gravity. This resulted in a long, tedious process, often requiring days. The resolution was often incomplete and the technique was not considered for routine analysis. As new stationary phases were developed, interest in liquid column chromatography intensified. These new stationary phases along wit recent developments in pressurized instrumentation have reduced the time of separation to minutes.

A typical chromatographic analysis can be divided into three steps. Sample Preparation involves getting the sample ready for introduction into the chromatographic system. It may involve removing suspended particulate matter, adjusting some parameter of the original solvent, or partitioning the constituent of interest into a more compatible solvent.

The actual Chromatographic Separation is the second step of the analysis. In this step the components of interest are spacially separated based on their absorption, partition, ion exchange and molecular exclusion interactions with the stationary phase in the column. Finally, after separation in the column the eluting fractions of interest must be Analyzed. The analysis can range from specific chemical analysis of discrete fractions collected to direct monitoring of the eluting stream. Such monitoring is usually accomplished by use of monochromatic absorption (usually in the ultraviolet spectrum) or by refractive index. When monitoring the eluting stream, identification is accomplished by comparing retention times (time from injection to detection) of the components to those of known standards. Quantitation is accomplished by comparing the magnitude of detector response to a calibration curve from the known standards.

PRESSURIZED LIQUID CHROMATOGRAPHY SYSTEM

The components of a HPLC system are diagrammed in the flow-schematic of Figure 1. The carrier solvent is pumped from a reservoir through a sample injecting device. This device may range from a fixed volume sample loop through a variable volume injector. Also the injecting devices range from manually operated through automatic injectors controlled by microprocessors.

The solvent then flows through a high pressure rated stainless steel column packed with an appropriate stationary phase. It is in the column that the spatial separation of solutes occurs. As the flow goes through the detector, an electronic output proportional to the amount of solute is monitored by a recording or integrating device. The effluent from the detector can either be collected or allowed to go to waste.

1/ Graduate Research Assistant and Associate Professor respectively in the Department of Plant Pathology and Crop Physiology.

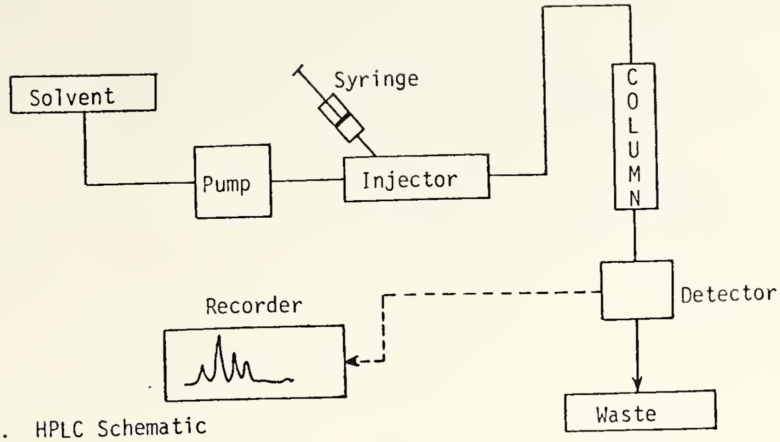


Figure 1. HPLC Schematic

The equipment used in the original phase of this study consisted of:

1. Waters Associate Liquid Chromatograph equipped with:
    a. Solvent delivery system
    b. Differential refractometer
    c. Syringe injection
    d. Solvent programmer
2. Sargent-Welch Recorder
3. Hewlett-Packard Reporting Graphic Integrator
4. Constant temperature circulating water bath

The modes of separation and stationary phases tested included:

1. Gel permeation
2. Liquid-solid absorption
3. Ion-exchange resin

The preparation of each column used is described by Wong-Chong (3). To prepare sugarcane juice samples for injection, celite was added to the juice sample and centrifuged at 10,000 x G for 10 minutes. The clear supernatant was made to 1:10 v/v dilution. Syrups and molasses samples were diluted before centrifugation. A fixed volume of 20 µl of each sample was injected.

Criteria of Performance:

Given low flow rates several modes of separation can fractionate the constituents of sugarcane juice. At the onset of this study it was decided that the minimum criteria of acceptable performance would be to separate a clean sucrose peak in a total run time of 10 minutes of less.

RESULTS

It has been reported that gel permeation resins give separation in the order of 90 minutes (3). However, none of the gel permeation resins tested were able to separate sucrose from reducing sugars in less than 10 minutes (3).

Using acetonitrile:water in the ratio of 80:20 as the eluting solvent through a Waters µBondapak-Carbohydrate column at the rate of 2.0 ml/min, a mixture of fructose, glucose and sucrose was separated in less than 10 minutes (3). However, the elution of the trisaccharide raffinose took 21 minutes with this system. Increasing the flow rate and increasing the polarity of the acetonitrile:water mixture both decreased the run time at the expense of the fructose-glucose resolution (3). By increasing the flow rate during a run through the use of a solvent programmer, the separation of glucose, fructose, sucrose and raffinose was achieved within 10 minutes (3). Although separation of a clean sucrose peak could be achieved with the µBondapak system, higher molecular weight compounds eluted at slower rates. This consideration would make it difficult to know when the last peak of a sample has eluted and render this system unsuitable for most routine laboratory analyses.

Of the stationary phases tested, the ion exchange resins show greatest potential for routine laboratory analysis. Maximum speed of separation and maximum resolution were attained with Aminex Q150S resin converted to the K^+ form. A 3/8 in. OD x 24 in. column kept at a constant temperature of 60° C was utilized. The eluting solvent was degassed, deionized-distilled water. Figure 2A shows a typical chromatogram of fresh cane juice. It was learned that dextran could be separated from sucrose, glucose and fructose with the system described above. However, other polysaccharides, salts and lactic acid emerge with dextran (Table 1). Because the products of degradation, dextran and lactic acid cannot be separated on this column, the peak ascribed to dextran would be more accurately labeled as salts and degradation products. Nevertheless, these products of deterioration are well separated from sucrose. Typical chromatograms of deteriorated juices are shown in Figure 2B and 2C.

Table 1. Retention-times for sugars, inorganic salts, and known deterioration products run on the Aminex Q150S K+ column.

	Retention-time
Inorganic salts	3.65
Dextran	3.65
Lactic acid	3.95
Acetic acid	4.30
Sucrose	5.40
Mannitol	6.45
Glucose	6.93
Fructose	7.45
Ethanol	7.95

As part of the original study, the results of the liquid chromatography and polarimetric analysis for fresh, moderately deteriorated, and badly deteriorated juice were compared. The correlations coefficients between the two methods ranged from 0.989 for fresh juices to only 0.460 for badly deteriorated juices (Figure 3A and 3B).

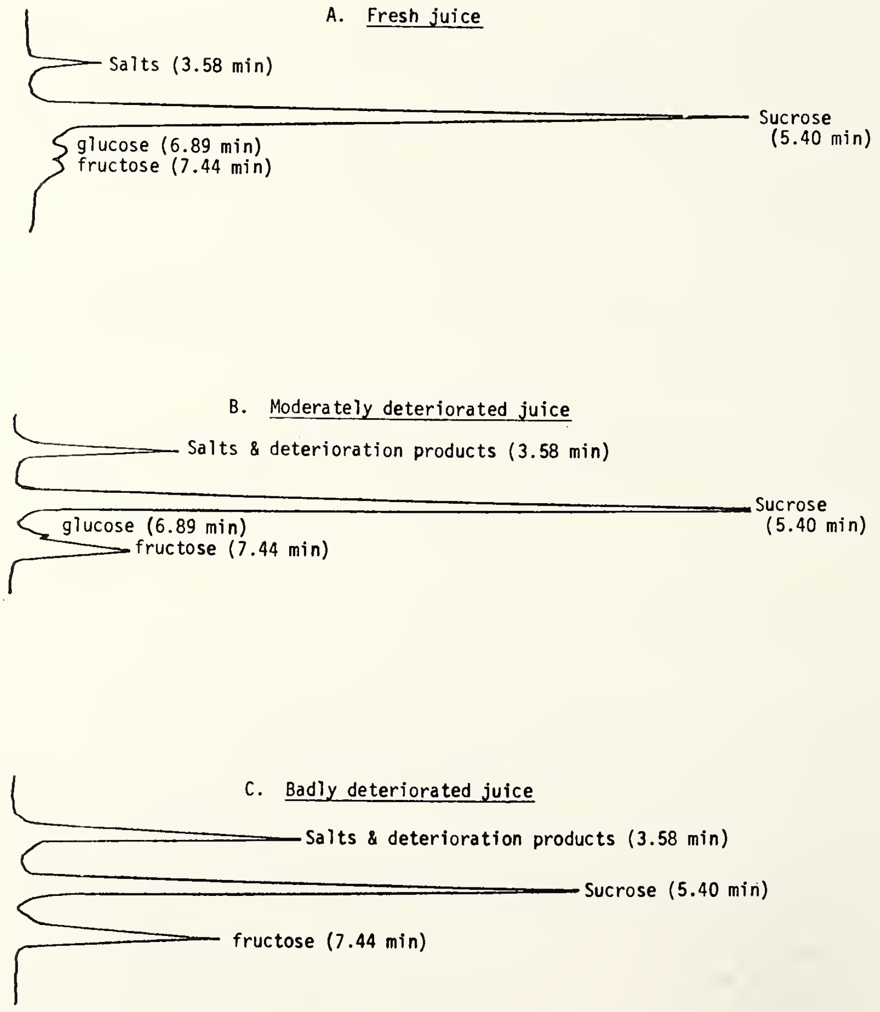


Figure 2. Chromatographic separation of juices on Aminex Q150s (K+) @ 2.5 ml/min.

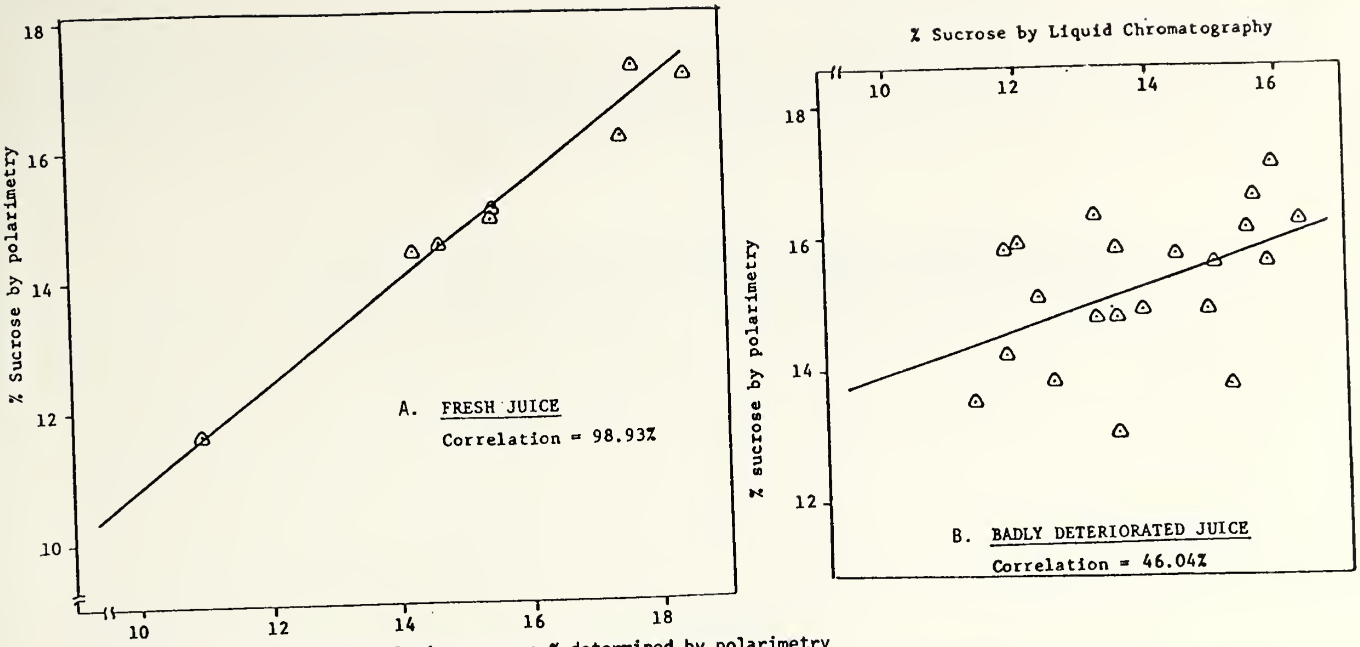


Figure 3. Scatter diagrams relating sucrose % determined by polarimetry vs. LC.

From these results it was concluded that liquid chromatography is superior to polarimetric analysis during periods when false pols may be experienced. Such periods usually follow a severe stalk-damaging freeze in Louisiana. The fact that HPLC measures deterioration products in the same run as the sucrose analysis should make it particularly attractive in a post-freeze period. However, it is unlikely that a HPLC unit would be purchased for use only after a severe stalk-damaging freeze. Serious consideration of HPLC would more likely be over the entire harvesting season. Therefore, for the last 27 days of the 1978 sugarcane harvest at the St. Martinville Sugar Coop., HPLC analysis was run on duplicates of pol analysis samples. The objectives were to again compare HPLC analysis to polarimetric analysis, and to study the feasibility of using HPLC in a Louisiana sugar factory. Comparison of HPLC sucrose and pol sucrose ranged from 0.9700 correlation on the day of best agreement to 0.7566 correlation on the day of least agreement (Figures 4A and 4B). The overall correlation for the 27 day period was 0.9094. This relatively high agreement was to be expected under the ideal harvesting conditions experienced in 1978. Under the conditions tested, 8 to 10 samples per hour could be run with HPLC.

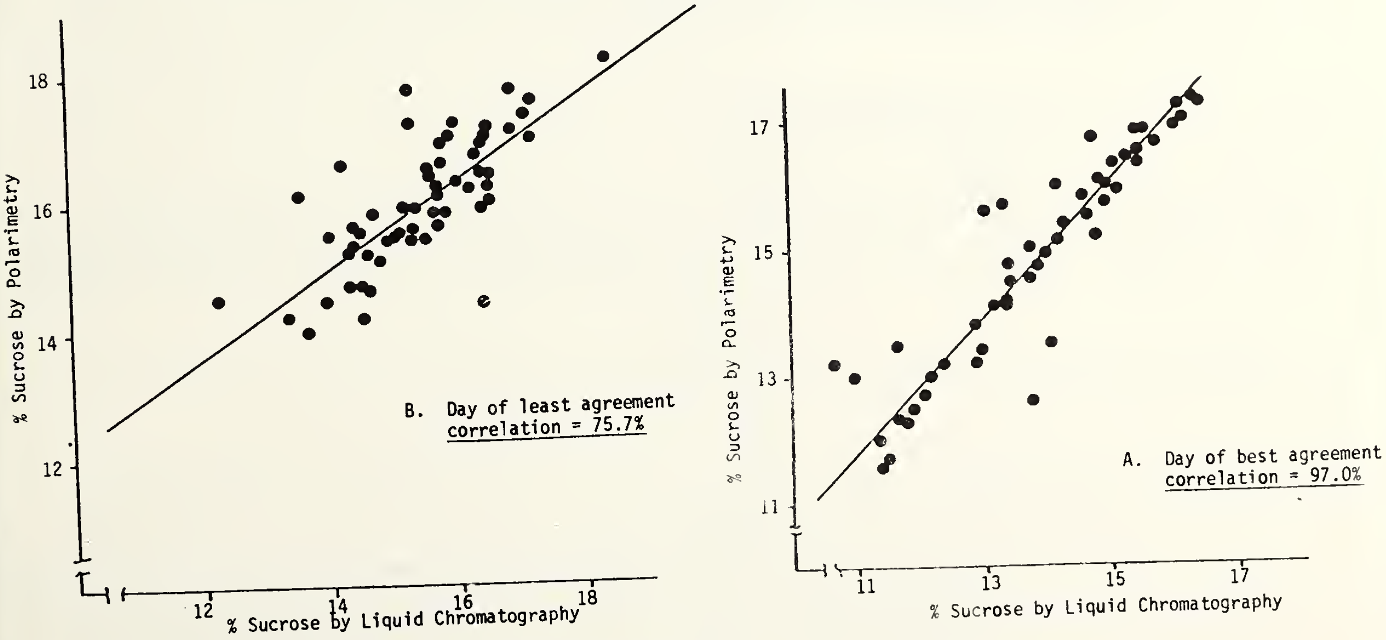
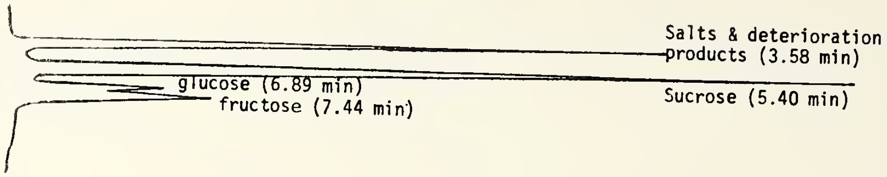


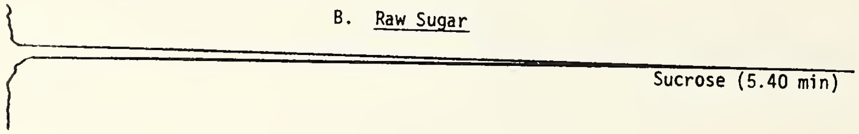
Figure 4. Scatter diagrams relating sucrose determined by polarimetry vs. LC.

Comparison of HPLC and polarimetric analysis was also made for sampling points in the mill. Analysis of these data reveals greatest disagreement in results for products of least purity. The differences in results were greatest for molasses samples where LC and pol estimates typically differed by 10% sucrose. A typical chromatogram of molasses is found in Figure 5A. A typical chromatogram for raw sugar is found in Figure 5B, and sucrose after acid inversion and neutralization in Figure 5C. All samples presently run in a sugar factory can be run by liquid chromatography on the Aminex Q150S K+ column.

A. Molasses



B. Raw Sugar



C. Products of acid inversion of pure sucrose

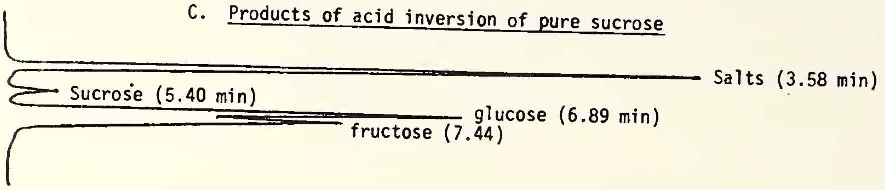


Fig. 5. Chromatographic separation of sugar-products on Aminex Q150s (K+) @ 2.5 ml/min.

In conclusion, when analyzing materials of high purity with no "false pol" content, HPLC sucrose estimates are virtually no better than polarimetric sucrose estimates. However, for those materials of low purity, HPLC is clearly more accurate and a superior method. HPLC is a dependable, rapid, and accurate method of measuring sucrose, glucose, fructose and degradation products of sugarcane and sugarcane products.

ACKNOWLEDGEMENTS

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CONCENTRATION OF CLARIFIED CANE SUGAR JUICE BY REVERSE OSMOSIS

R. Chang[1/] and J. P. Merle[2/]
Chemical Engineering Department
Louisiana State University
Baton Rouge, Louisiana

ABSTRACT

Reverse osmosis utilizes a high pressure to overcome the osmotic pressure of the solution and thus force pure water across a semi-permeable membrane. This process requires much less energy compared to more traditional techniques of water removal such as multiple effect evaporation. A 20 ft^2 polyamide spiral wound membrane was used to study the feasibility of concentrating a cane clarified juice solution following pretreatment through a 5 micron polypropylene cartridge filter. In addition to clarified juice, pure water and pure sugar solutions were also tested at various temperatures, pressures and concentrations. At an operating pressure of 450 psig, the flux values obtained ranged from 0.44 gallons/ft^2/day for clarified juice at 110°F to 36.71 for pure water at the same temperature. Typically, the average flux over a juice concentration range of 10 to 25° brix was 5.0 gallons/ft^2/day at 110°F and 450 psig. In spite of the pretreatment step, fouling of the membrane was a major obstacle as the flux decreased by 50% over a 48 hour period of continuous operation. However, cleaning with a 2% sodium borate solution restored most of the flux. The permeate (water) separated from the sugar solution was very pure, yielding a sucrose rejection of 100 % in all cases. In spite of considerable savings in energy requirement, removal of water from cane clarified juice by reverse osmosis is not economically justifiable at the present stage of membrane technology. The large surface area required and the replacement and maintenance cost of the membrane outweigh the benefits derived from energy savings.

INTRODUCTION

During recent years, reverse osmosis has been applied successfully to the recovery of fresh water from sea and brackish water on a large scale. A 3.2 million gallons/day desalination plant was recently installed in Saudi Arabia (1). The technology was also widely adopted by the food industries, particularly the dairy and maple sap industries (2). Madsen (3) reported his experimental work on mixed juice, cold lime juice and clarified juice using a cellulose acetate membrane. Generally, application of reverse osmosis in the cane sugar industry has so far proved unsuccessful because of low permeate flux and ensuing flux decay due to membrane fouling.

EXPERIMENTAL APPARATUS AND PROCEDURE

The experimental apparatus used in this study is shown in Figure 1. The clarified juice solution in tank T1 is pumped through the 5 micron cartridge filter to tank T2 equipped with a stirrer S1. From tank T2 the solution is pumped by the multistage centrifugal pump P through the reverse osmosis unit RO which separates the solution into a permeate and a concentrate stream. Pressure gauges PG1 and PG2, conductivity meter CM and flowmeters FM1 and FM2 monitor the operation. Operating pressure is controlled by throttling the globe valve V. The modes of operation are summarized in Table 1.

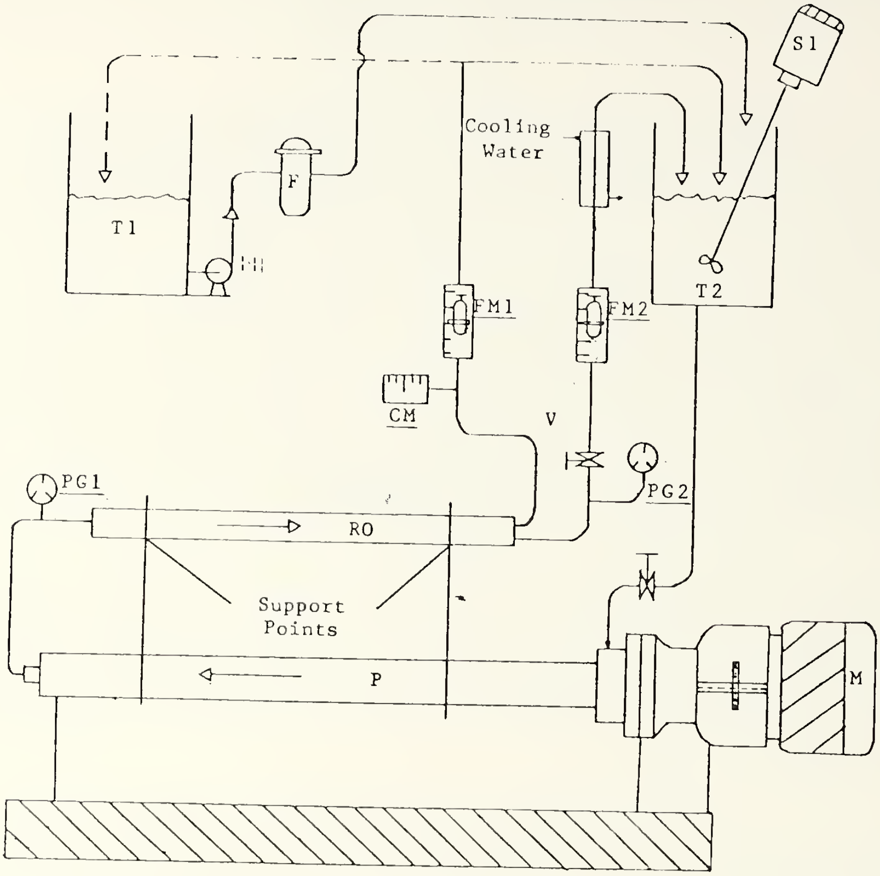
Table 1

	Operating Conditions			
Solution	Conc., ° brix	Operating Pressure psig	Temp. °F	Time (Hours)
Pure Sugar	4.6, 9.5	200, 250 300, 375 450	75-115	-
	13.0	250, 300, 375, 450	75-115	-
	13.0 - 21.8	450	113	-
Clarified Juice	10 - 25	450	75-115	up to 48
Pure Water	-	200, 250, 300, 375, 450	75-115	-

The feed flow rate to the reverse osmosis unit varied from 4 to 8 gpm.

1/ Present address: Accurex Corp. 485 Clyde Ave., Mountain View, CA 94042.
2/ Present address: C & H Refinery, Crockett, CA 94525.

Figure 1. Experimental Apparatus



RESULTS AND DISCUSSION

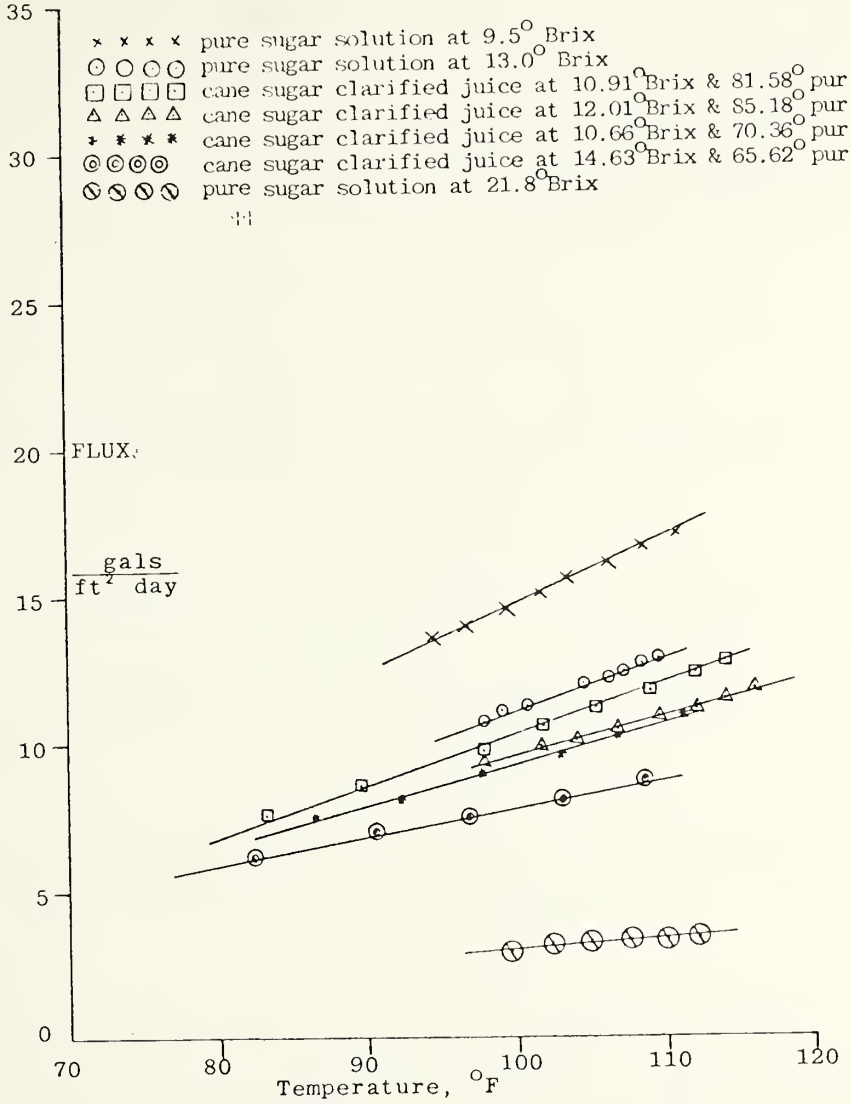
At constant concentration and purity, the flux increased linearly with temperature and pressure. Figure 2 shows the increase in flux with temperature for various sugar solutions. From this figure, it can be observed that the temperature dependence decreases with increased concentration. The effect of purity is also apparent when comparing the clarified juice at 12.01° brix and 85.18° purity with that at 10.66° brix and 70.36° purity.

The variation of flux with time is shown in Figure 3. The extended run on the clarified juice sample at 10.6° brix reveals that, due to fouling of the membrane, a loss of 46% in flux was sustained in 48 hours. In a separate run (Figure 4) a similar time study was carried out with clarified juice at 14.6° brix, 65° purity but in this case the flow of juice was discontinued every eight hours and the membrane was cleaned with a 2% solution of sodium borate. Most of the original flux was restored after the first cleaning while essentially all of the flux was recovered after the second treatment with sodium borate.

While it is encouraging to note that the membrane can be effectively cleaned, the rapid decline of flux is of concern since this necessitates frequent equipment shutdown for flux regeneration, the cost of a parallel unit for continuity of operation and the cost of the chemical agent itself.

A clarified juice sample at 10.36° brix was concentrated to 25.21° brix at 450 psig and 110.75°F. Twelve and twenty-six one hundredths (12.26) gallons of permeate were collected in 2.933 hours. The average flux for the run was 5.02 gallons/ft^2/day. Based on these figures, 120,000 ft^2 of membrane surface area would be required for a factory grinding 4000 tons of cane per day. Equipment limitation restricted operation to a maximum of 450 psig operating pressure. In practice, higher pressures and temperatures could be used. Assuming the higher values of temperature and pressure result in twice the flux figure obtained in the experimental run, 60,000 ft^2 of membrane surface would still be required.

Figure 2. Variation of flux with time at 450 psig operating pressure.



The sucrose rejection of the membrane was 100 in all cases while the ash rejection varied from 95 to 99. While it is important to secure as high a sucrose rejection as possible, it is possible to obtain a higher flux with a "looser" membrane that will allow more ash to pass through but will still reject all the sucrose.

The experimental membrane (supplied by UOP, San Diego, Energy Savings California) lasted 153 hours.

It would be interesting at this point to examine the energy savings using reverse osmosis as partial replacement for evaporation.

Suppose 1 million gallons of clarified juice per day are to be concentrated from 10.36° to 65° brix. Two methods of concentration will be compared:

i) using a triple effect evaporator
ii) using reverse osmosis to bring the concentration to 25.21° brix and then completing the evaporation to 65° brix in the triple effect evaporator.

It is assumed that exhaust steam is available at 30 psia and that a vacuum of 26" Hg prevails in the last cell. Furthermore, it will be assumed that the steam economy is 2.5.

Figure 3. Variation of flux with time at constant pressure (450 psig), temperature (114°F).

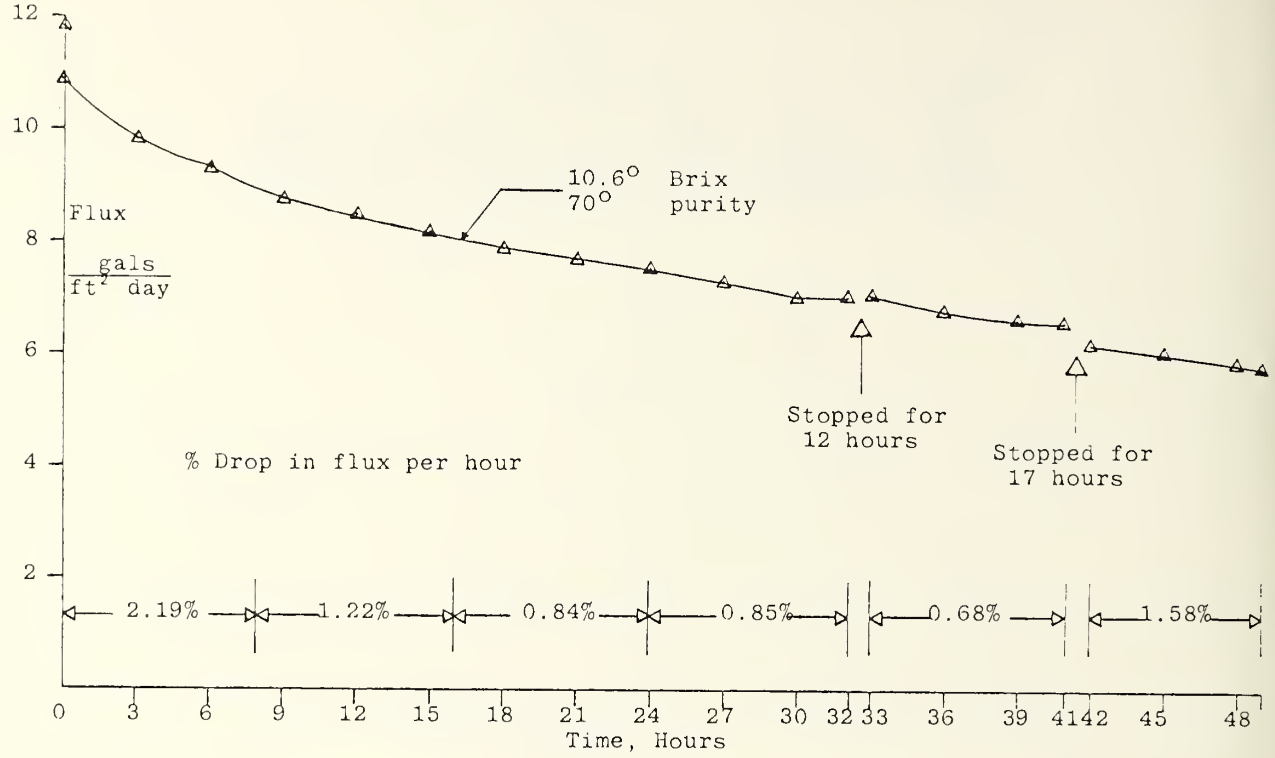
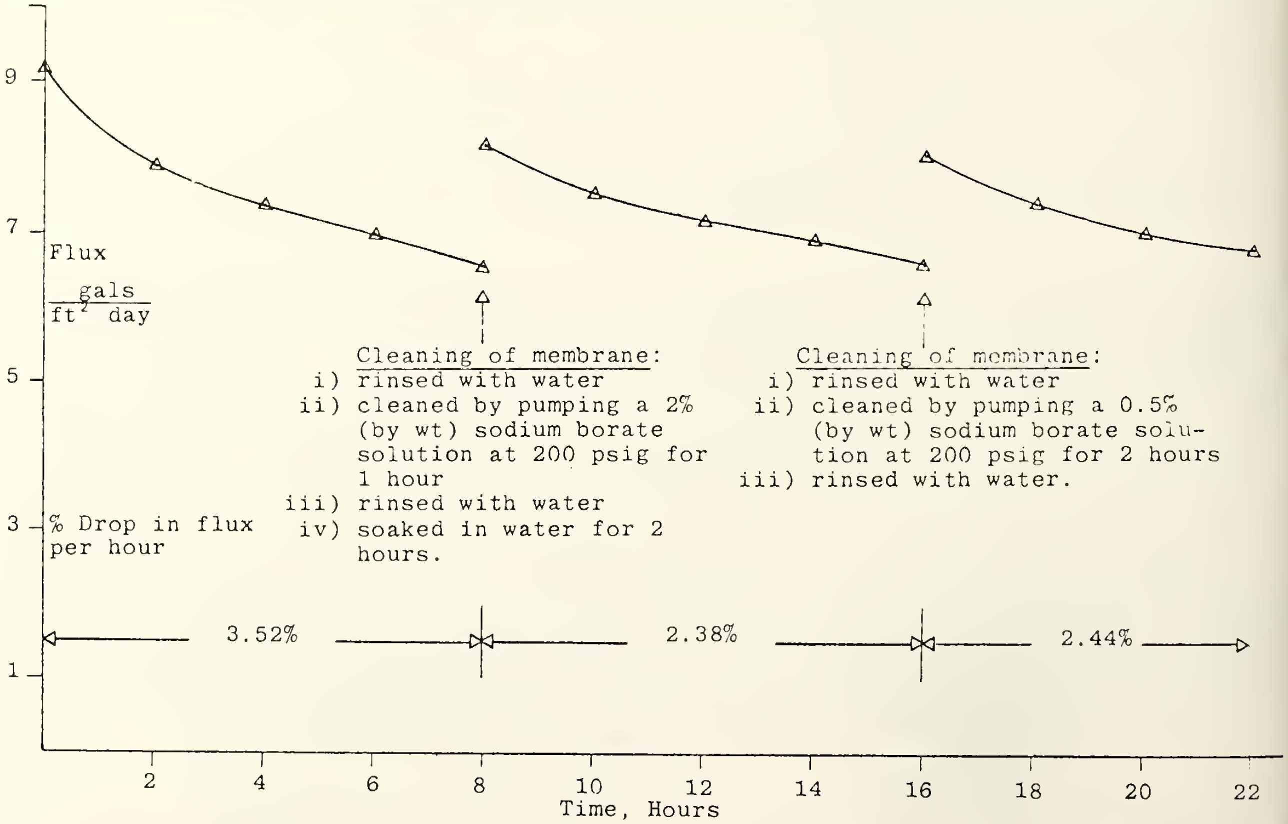


Figure 4. Variation of flux with time at constant pressure (450 psig), and temperature (114.8°F).



Cleaning of membrane:
- i) rinsed with water
- ii) cleaned by pumping a 2% (by wt) sodium borate solution at 200 psig for 1 hour
- iii) rinsed with water
- iv) soaked in water for 2 hours.

Cleaning of membrane:
- i) rinsed with water
- ii) cleaned by pumping a 0.5% (by wt) sodium borate solution at 200 psig for 2 hours
- iii) rinsed with water.

i) Evaporation from 10.36° to 65° brix

$$\% \text{ Evaporation} = \left(\frac{65 - 10.36}{65}\right) 100 = 84.06$$

$$\text{Water to be evaporated} = (10^6)(8.65)(0.8406) = 7{,}271{,}190 \ \frac{\text{lbs}}{\text{day}}$$

$$\text{Steam required} = \frac{7{,}271{,}190}{2.5} = 2{,}908{,}476 \text{ lbs/day}$$

$$\text{At 30 psia, BTU/day required} = (2{,}908{,}476)(945.3) = 2.75 \times 10^9$$

ii) R.O. from 10.36° to 25.21° brix followed by evaporation to 65° brix

$$\% \text{ water removal by R.O.} = \frac{(25.21 - 10.36)}{25.21} \ 100 = 58.91$$

$$\text{Water removed from R.O.} = (10^6)\ (8.65)\ (.5891) = 5{,}095{,}715 \ \frac{\text{lbs}}{\text{day}}$$

$$\text{Clarified juice entering the evaporator} = (10^6)(8.65)(.4109) = 3{,}554{,}285 \text{ lbs/day}$$

$$\text{Gallons clarified juice per minute} = (10^6) \div (1440) = 694.4$$

Suppose the operating pressure is 750 psig and the pump efficiency is 60%

$$\text{H.P. required} = \frac{(694.4)(750)(2.31)(1.04)}{(3960)(0.60)} = 527$$

$$\text{BTU per day} = (527)(1440)(42.44) = 0.0322 \times 10^9$$

$$\% \text{ water removal by evaporation} = \frac{(65 - 25.21)(100)}{65} = 61.22$$

$$\text{Water evaporated} = (3{,}554{,}285)(.6122) = 2{,}175{,}933 \text{ lbs/day}$$

$$\text{Steam consumption} = \frac{2{,}175{,}933}{2.5} = 870{,}373 \text{ lbs/day}$$

$$\text{At 30 psia, BTU/day} = (870{,}373)(945.3) = 0.823 \times 10^9$$

$$\text{Total BTU/day} = (0.823 + 0.032)10^9 = 0.855 \times 10^9$$

$$\% \text{ energy saving} = \frac{2.75 - 0.855}{2.75} (100) = 68.9$$

A simple cost analysis will show that the savings in energy cannot compensate for the capital cost required to install and operate the reverse osmosis unit.

CONCLUSIONS

Flux increases with increase in operating pressure, temperature, and purity, and decreases with increasing concentration. In all cases, there is total rejection of sucrose and very high rejection of ash. The flux decreases fairly rapidly with time due to fouling of the membrane surface. However, cleaning with a 2% sodium borate solution restores most of the flux. Pretreatment of clarified juice is essential. In spite of the energy savings, the reverse osmosis process cannot compete with multiple effect evaporation for removal of water from clarified juice. The main reasons for this are: low flux values, membrane fouling and membrane life. With increased energy costs and improved membrane technology, reverse osmosis could eventually find its place in the cane sugar factory.

ACKNOWLEDGEMENTS

We would like to thank the Audubon Sugar Institute for support of our research efforts.

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CORROSION IN THE SUGAR FACTORY

by
S. J. Clarke and D. F. Day
Audubon Sugar Institute
Louisiana State University
Baton Rouge, Louisiana 70803

INTRODUCTION

Corrosion may be defined as the deterioration of a structure or part of a structure due to the action of the total environment or individual environmental agents. The corrosion of metals is by far the most important and is the subject of this paper. Two types of corrosion are distinguished - chemical corrosion and electrochemical corrosion. The first involves the reaction of metals with substances such as oxygen and sulphur dioxide, often at high temperatures, and is not of too great importance in the sugar industry, except for perhaps the contact of boiler tubes, etc. with the furnace gases. Electrochemical corrosion occurs in the presence of moisture and it is this type of corrosion that is of greatest concern.

Corrosion in the raw sugar factory has been the subject of much discussion over the years and an extensive review of the related problems in the sugar beet industry has been published by Travanelli et al.(1). The present paper attempts to focus on some aspects of corrosion in the raw cane sugar factory and to suggest partial remedies for some of the more serious problems.

THE CORROSION PROCESS

Corrosion may be regarded as the tendency of metals to revert to the natural state, i.e., to the ore from which the metal was produced. Very few metals exist in nature in the elemental form and these are quite unsuited to the process we are considering. The reversion to the oxides of all the industrially important metals, iron, copper, aluminum, etc., is energetically favorable. It is therefore not possible to completely prevent corrosion but corrosion can be markedly reduced if the appropriate precautions are taken.

The cost of corrosion to the industry may be listed under the following headings: (a) direct costs related to the replacement of damaged equipment, (b) indirect costs due to (i) stoppage or decreased performance, e.g., decreased heat transfer or mechanical strength or (ii) decrease in the quality of product due to contamination by interaction with corrosion products, (c) additional costs due to use of more expensive corrosion resistant materials, inhibitors and coating materials.

In order for electrochemical corrosion to occur, the metal must be in contact with a solution which is able to conduct an electric current to form a corrosion circuit (Figure 1) with the metal. The current flowing in the circuit determines the rate of corrosion of the metal - the rate at which the metal passes into the solution. The current is determined by the difference in electrode potential between the anode and cathode and by the resistance of the circuit.

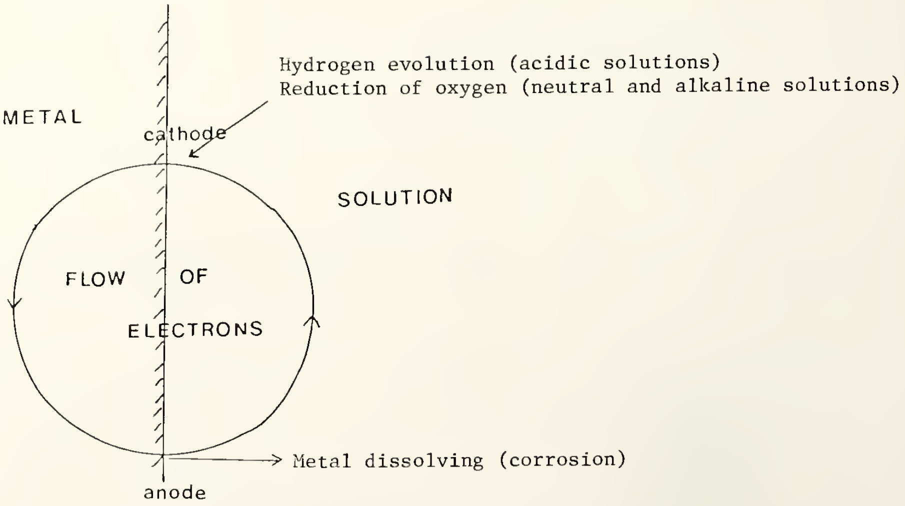
Hydrogen evolution (acidic solutions)
Reduction of oxygen (neutral and alkaline solutions)
METAL
cathode
SOLUTION
FLOW OF ELECTRONS
Metal dissolving (corrosion)
anode

Figure 1. The Corrosion Process

If two different materials are in contact with each other and with the same solution then the difference in potential of the anodic and cathodic sites may be quite high and rapid corrosion of the more active metal may occur. When the solution is in contact with a single metal, anodic and cathodic sites are still present due to the uneven character of the metal surface. Corrosion is more likely to occur, i.e., the anodic site will be present, at an area where the metal is under stress, at grain boundaries at welded joints, where cracks have been formed and where there is a deficiency of oxygen relative to the rest of the solution. Corrosion rate is often expressed as the average loss of thickness of the metal with time but this can be very midleading since corrosion at a very small area of the metal, e.g., pitting, can be very rapid, even though the overall loss of metal is very small. The electrical resistance of the circuit is usually determined by the ease of transfer of charge at the anodic and cathodic sites. Passivation of a metal is the formation of a surface coating of corrosion product, usually the oxide or hydrated oxide, on the metal and this layer has a high electrical resistance which reduces the current flowing in the circuit with corresponding decrease in the rate of corrosion. The use of inhibitors also results in increased electrical resistance at the surface of the metal. Cathodic inhibitors, e.g., chromates, phosphates, carbonates, etc., promote the formation of a layer of poorly conducting material on the metal and are most useful in neutral and alkaline solutions, e.g. boiler feed water. Anodic inhibitors are usually organic substances which are absorbed onto the metal surface to form a barrier between the metal and the solution, again increasing the resistance of the corrosion circuit. These inhibitors, often alkyl amines or thioureas, are of greatest importance in prevention of corrosion in acidic solutions. Some inhibitors of this type are not very stable in acidic solution and will lose their activity over a period of time. It is therefore unwise to use acid to which the inhibitor was added at manufacture or to assume that previously inhibited acid can be reused safely. The inhibitor should be added to the acid just prior to its use. Differences in the corrosion characteristics of similar metals often arise due to the polarization of the metal surface, i.e., the ease with which the metal is lost to solution. Increased polarization means increased resistance and therefore lower corrosion rates. Nickel, for example, is far more polarized in acid solution than is iron.

It is usually fairly easy to choose a suitable metal for a vessel when the conditions under which it is to be used are constant, e.g. the clarifier. When the process demands that the conditions are varied dramatically, e.g., the evaporators, then the choice is more difficult. Any protective layer formed during the normal running of the evaporator and in treatment with caustic soda will be removed by the acid during the final stage of cleaning.

TYPES OF CORROSION

Corrosion may be thought to occur as general corrosion or as localized corrosion. General corrosion involves loss of material from all the surface and may usually be planned for by using a suitable thickness of metal. Localized corrosion involves loss at a particular area, often rapidly and at a critical part of the structure. Intergranular and pitting corrosion are examples of localized corrosion. Pitting corrosion in steel is accelerated by the presence of chlorides. Corrosion is greatly increased when the metal is under stress and when abrasion occurs due, for example, to the presence of a solid such as sand or to the rubbing together of metal surfaces. The metabolic activity of microorganisms can cause deterioration of metals by creating a corrosive environment or influencing the rates of the anodic or cathodic reactions. This is known as biological corrosion.

SITES IN THE SUGAR FACTORY AT WHICH CORROSION OCCURS

There is no single corrosion problem in the sugar industry, rather a series of problems depending on the operation involved. Some process steps, e.g., clarification, are associated with negligible corrosion whereas later steps may involve very serious corrosion.

Corrosion which occurs at the wash table and the mill is principally due to the acid materials present at this stage of the process. Biological corrosion can become a serious problem at the wash table and this is discussed in more detail later. Mill corrosion problems are usually slight providing that adequate mill sanitation procedures are followed.

There are usually no corrosion problems at the liming station and at the juice heaters if a cold liming process is used. Scaling, and therefore the need for its removal is not a serious problem since the presence of solid material and the high velocity of the juice does not allow serious scale formation. When hot liming is practiced, the juice heaters may suffer from erosion corrosion due to the acid pH of the untreated juice.

Evaporator corrosion is very much associated with the need for scale removal and is discussed later in this paper. Corrosion at the vacuum pans is not very serious, due in part to the lack of scale as a result of the scouring action of the sugar crystals. Stress related corrosion has been noted in the centrifugals, especially when a high chloride concentration occurs in the molasses (1). Corrosion of the insulated surfaces of boilers and steam pipes has been observed and related in part to the intermittent operation of the factory and the nature of the fuels used (2).

EVAPORATOR CORROSION

Evaporator cleaning and corrosion in Louisiana has been the subject of several studies over the years (3,4). Our recent survey of some of the scaling and corrosion problems of the industry reveals a considerable diversity of situations. Some factories seem to have overcome these problems whereas others have serious difficulties with corrosion. Quantitative data on corrosion is extremely difficult to acquire and the survey asked that corrosion be classified as severe, moderate, mild or absent. By giving these classifications arbitrary weightings of 4 (severe), 2 (moderate), 1 (mild) and 0 (absent), it is possible to make a rough correlation of the corrosion with other factory data. The assessment of corrosion, e.g., as mild or moderate, depends very much on the experience of the observer and any conclusions from such an analysis should be used as a basis for a more detailed investigation. The information regarding scaling on the questionnaire was treated in the same way. Thus, for the three seasons (1976, 1977 and 1978) and for the three vessels in a triple effect, a maximum of 36 points (4 for severe corrosion of each vessel in each season) could be obtained. This analysis does not allow for variation in the type of scale in each vessel. Although a rather unsatisfactory method of data analysis, it does give some indication of where the problems lie.

No clear relationship was apparent between scaling and the quantity of lime used in clarificaton or the pH of the juice after liming. Increased corrosion could be related to the pH of the clarified juice (Fig. 2) and to the severity of the scaling (Fig. 3). Two factories out of 20 stand out as having much more severe corrosion problems and one reported no corrosion at all.

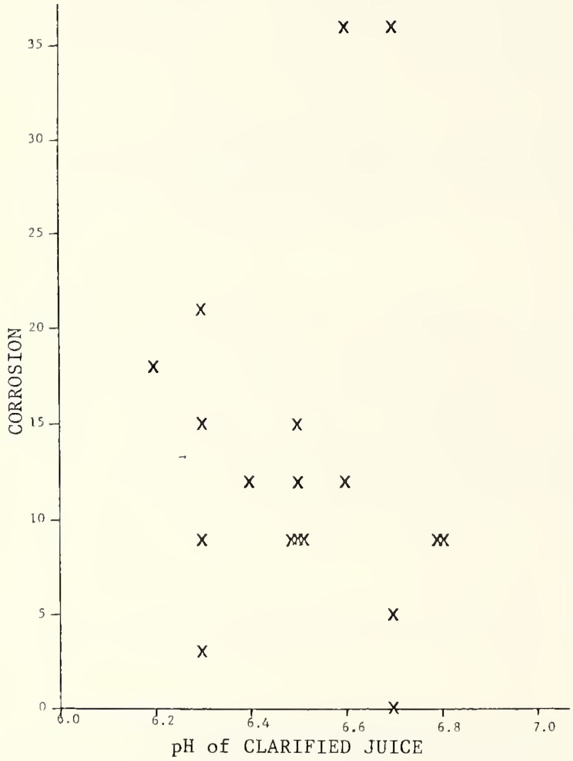

Fig. 2. Plot of pH of clarified juice against corrosion in evaporator.

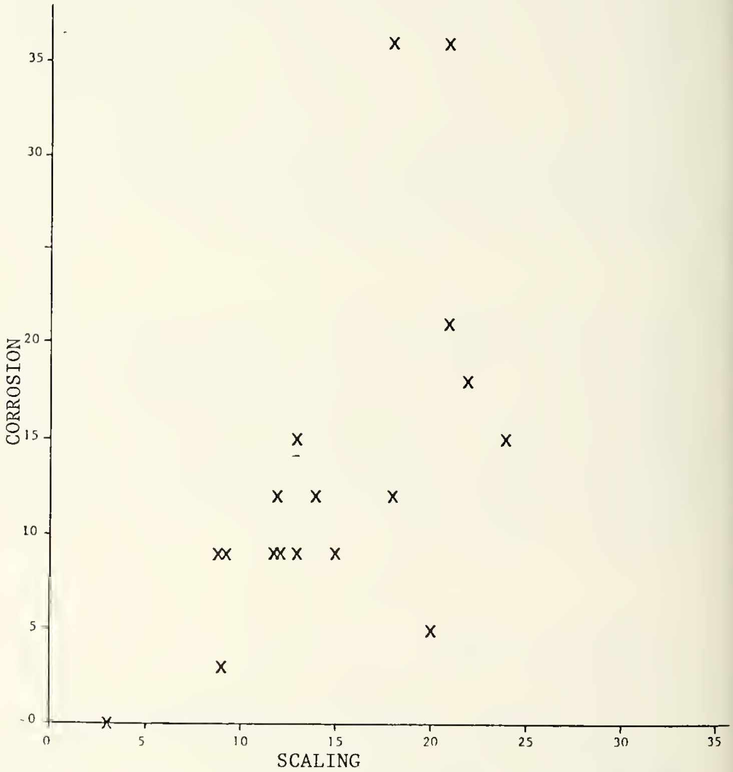

Fig. 3. Plot of scaling against corrosion in evaporators.

The problem could be avoided almost completely if no scaling occurred and the evaporators could be run under constant conditions. Scale avoidance can only be complete if the clarified juice was subjected to softening by ion clarified exchange but this is economically impossible at present. Scaling can be minimized by careful control of the clarification process and it is noteworthy that many of the Louisiana mills operate the clarifier at a lower pH than most areas. Although this does to some extent minimize scaling by keeping the lime concentration in the juice low, operating the clarifier at a lower pH can increase corrosion. This is evident from the data received from the survey of mills in Louisiana--mills operating at low pH tended to have more corrosion problems. Evaporation of the juice to syrup can produce a decrease in pH, again favoring corrosion.

The cleaning process used now in most factories is essentially the same as reported by Keller in 1939 (3) except that inhibitors are in general use for the acid treatment. At that time the mills tended to be smaller and the evaporators often constructed of copper which is the most suitable metal, both from the standpoint of heat transfer and of corrosion resistance. At least one factory in Louisiana is now operating a set of evaporators with an all copper callandria;this has been in use for over twenty years without problems. This is obviously the best solution in that it avoids the use of different metals in contact with each other and also uses a metal of low reactivity. However, as the mills have expanded and the cost of copper has increased, it is no longer feasible to construct an all copper system. It has become necessary to use less suitable metals or alloys, sometimes in combination with copper. A brass tube plate with copper tubes is quite satisfactory but there can be a loss of zinc from the brass. From the points of view of cost and mechanical strength, steel is an obvious choice, but in combination with metals such as copper the steel is likely to corrode extremely rapidly. There have been cases where steel tube plates (used with brass tubes) have only lasted two seasons. If at all possible, the combination of dissimilar metals should be avoided. If this is not possible then the more active metal should show high polarization characteristics. Nickel is such a metal and there has been considerable success with the use of nickel clad steel in evaporator construction.

Stainless steel suggests itself as a suitable metal and its use in the sugar industry has been discussed (5). Pitting and stress related corrosion are problems, particularly since quite high concentrations of chloride are present in the juice. Hydrochloric acid should be avoided in the cleaning procedure. The combination of stainless steel tubes with mild steel plates can behave as a dissimilar metal system resulting in severe corrosion of the tube plates.

Much corrosion could be prevented if an alternative to the acid cleaning procedure could be used. Scale removal by chelating agents such as versene (ethylenediamine tetraacetic acid) is very effective but, unfortunately, very expensive. Sulfamic acid has less tendency to cause pitting in steel and is an effective and convenient alternative to hydrochloric acid.

A more immediate approach is to review critically the concentrations of cleaning agents used and the time and temperature of boiling. A procedure that has worked well in the past for a vessel constructed of copper is not necessarily suitable for a vessel constructed partly of steel. The minimum concentration of acid required for effective cleaning should be determined by decreasing the concentration of acid until diminished results are observed. Indicators may be added to the acid to show when it is spent, thereby allowing only a slight excess of acid to be used. The need for fairly high concentrations of caustic soda, with or without soda ash, is fairly well established (6).

For good performance the only metallic surfaces in the evaporator that must be in contact with the juice are the tubes. It should be possible to coat the rest of the vessel with a non-metallic material. This would be most important for the tube plates if they are of an inferior metal to the tubes. Glass lined vessels are used widely in the chemical industry and the possibility of polymer coatings should not be overlooked.

CANE WASH TABLE

Severe corrosion of wash table carrier chains is found in about 35% of Louisiana's raw sugar mills. It shows up as significantly shortened operating lives for the carrier chains, in some cases, chains will not last more than one campaign. The primary cause of this problem is the continual bathing of the wash table with acid wash water.

Acid wash water is the direct result of recycling cane wash water. Water as it comes off the wash table has an appreciable BOD_5 (200-600 mg/l) and contains a large amount of suspended solids (1500-2000 ppm) of which only 60% is removed by settling (7). The bulk of the BOD input is in the form of carbohydrate. Mixed microbial populations present in the wash ponds will convert the carbohydrates through a progression of products, ultimately oxidizing them to carbon dioxide and water. This oxidation takes place in two stages, the first in the absence of air (anaerobic) results in the production of organic acids. The organic acids are then converted in the presence of air (aerobic) to carbon dioxide and water. The complete oxidation is dependent upon a number of parameters.

1. Sufficient time for complete oxidation
2. Enough other nutrients, nitrogen and phosphorus, to maintain a balanced population
3. Sufficient air for complete oxidation

A lack of any of these elements will result in incomplete oxidation, usually oxidation only to the stage of organic acids. And of course, high organic acid production will result in a pH drop and ultimately in wash table corrosion.

A survey of Louisiana raw sugar mills has highlighted certain common factors in mills reporting wash table corrosion problems.

		Wash Rate		
Mill	% Water Recirculated	Gal/Ton	Gal/Min[a)]	pH of Wash Water
1	100	1,720	3,000	5.5
2	100	2,432	6,000	4.8
3	100	4,492	10,000	4.5
4	100	2,609	6,000	6.0
5	100	1,503	5,500	-

Total mills reporting = 18
Problem mills = 5

a) Figures obtained from the Gilmore Sugar Manual

All the mills with this problem use 100% recycled water for cane washing. They generally use a large amount of water per ton of cane (1500 gal/ton or greater) and recirculate at more than 5000 gal/min. In themselves, none of these factors is important, but if combined with a small volume holding pond they indicate conditions suitable for the development of acid wash water. A rapid reuse of wash water with a continuous carbohydrate input will not give sufficient time for complete oxidation. This condition effectively favors the anaerobic process. Large microbial populations will develop which because of their numbers use up all the dissolved oxygen in the holding ponds, maintaining the anaerobic condition and effectively blocking the conversion of organic acids to carbon dioxide and water. This population will continuously produce organic acids and continue to do so as long as the cane is being washed. Raising the pH of the pond by liming or adding caustic will not affect acid production and so will only have a very temporary effect.

The best solution is a holding pond large enough to remove the added BOD before the water is reused. But in some cases because of land limitations, this is not always possible. However, proper adaption of sanitary engineering techniques in holding pond design and the use of aeration can appreciably decrease the required pond size. Wash table corrosion due to acid wash water is a problem, which, with intelligent handling, should be resolvable.

CONCLUSION

Corrosion control is inevitably a compromise between the use of expensive materials with desirable properties and of less expensive materials with poorer corrosion resistance. The choice of material is critical and if possible, short term savings should be avoided. Proper operating procedures, e.g. clarifier control and the correct use of inhibitors and recycled wash water can minimize corrosion to an acceptable level.

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OBSERVATIONS ON THE LOUISIANA CORE SAMPLERS

by
Harold S. Birkett
F. C. Schaffer & Associates, Inc.

There are now seven Louisiana sugar mills using the core sampling system. This paper presents the replies from a questionnaire sent to all of the mills with core samplers. All mills replied to the questionnaire. The questions covered included:

1. The corer's reliability and performance
2. The pre-breaker's reliability and performance
3. The hydraulic press' operating conditions
4. The laboratory facilities
5. Corer system and operating costs
6. Sampling frequency and labor requirements
7. Payment methods
8. Grower and factory personnel comments
9. Comparison of Corer's Liquidation factor with yield per standard ton.

INTRODUCTION

Development work was conducted on the core sampler in 1972, 1973, and 1974 at the Audubon Sugar Factory (LSU), and at Cinclare Central Factory in Brusly, Louisiana. The first commercial Louisiana corer was installed at the St. Martin Sugar Cooperative in 1975. The following table shows how the number of Louisiana sugar factories using core samplers has increased in recent years.

Table 1. Number of Corer Installations in Louisiana.

Year	Number of Operating Mills With Corer	Number of Operating Mills Total	% With Corer
1974	0	37	0.0
1975	1	35	2.9
1976	1	35	2.9
1977	2	33	6.1
1978	7	28	25.0

Several additional mills have shown interest in core samplers and the number of mills using core samplers is expected to increase in the future.

Corer: To the question "How reliable was the corer?", the responses were:
Very reliable
Quite reliable (20 hours lost time)
95% reliable
Most reliable
Reliable
Lost half-day
Lost 3 hours during crop

The reasons for down time on the corers were due to:
Bent coring table
Faulty switch
Carriage latch malfunction
Changing of cutter ring (twice)

Pre-Breaker: The pre-breaker is a sample preparation device that shreds the cane without extracting any juice. The shredded cane is then sub-sampled and sent to the laboratory for analysis.

In response to the question on reliability of the pre-breaker only one mill indicated that it was not entirely satisfied with the dependability of the pre-breaker. One mill suggested that a finer preparation would be desirable, while another mill felt that there was "some question under muddy conditions." One mill recommended that the anvils and hammers be changed every 10,000 samples.

Hydraulic Press: The hydraulic press is used in the lab to separate the cane sample into juice and bagasse fractions for analysis.

All mills operated the hydraulic press so as to exert a pressure of 3600 psig on the sample. Four mills pressed the sample for 3 minutes, while the other three mills used a 2 minute pressing cycle.

Laboratory Facilities: The laboratory analyses consist of: (1) weighing the cane and bagasse samples, (2) analyzing the juice for pol and Brix, and (3) determining the moisture content of the bagasse.

Five of the seven factories erected new independent laboratory buildings to handle the grower samples, while two mills used the existing factory control lab.

Four of the seven factories used quick operating electronic scales to perform the weighings.

All mills used refractometers to determine the juice Brix, and two mills used automatic (digital) polariscopes for the pol determinations.

All mills had at least one convection oven for determining the bagasse moisture. Some mills had four ovens, although the average mill had 2.4 ovens.

Some mills used microwave ovens to speed up the moisture determinations. The number of microwave ovens at a factory varied between none and two, with the typical factory having one microwave oven.

Data Handling: All seven factories use a computer to calculate and tabulate the corer results. Five mills use a service bureau with costs varying from $3,200 to $7,500 and averaging $4,800 per year. Two mills purchased computer systems that cost $23,400 and $27,000 respectively. These two mills also utilize these computers for factory payroll, daily and weekly reports, etc.

Total Corer System Cost: The total cost of the corer installation including the hydraulic press, laboratory building and lab equipment ranged from $95,000 to $145,000 with an average of $121,000. These costs exclude that of the first corer installation which was installed at an introductory price.

Sampling Frequency: Prior to the installation of the core sampler the samples analyzed per day varied between 33 and 90 with an average of 70. Following the installation of the core sampler these mills analyzed between 70 and 122 samples on a typical day, to give an average of 96 samples per day.

Labor Requirements: Labor requirements for the core sampling system varied from 3 to 6 people with an average of 4.9. These same mills had previously employed between 7 and 16 people with an average of 8.9 people to operate the conventional cane sampling system.

Payment Method: The total payment for cane is based on sugar and molasses produced and on hauling.
Sugar: The percentage of the sugar sales paid to growers varied from 60 to 64.2% with an average of 61.9%.
Molasses: Two mills based the molasses payment on the gross cane delivered. Three mills based the payment on "net" cane where the trash content was obtained from typical values of previous years. One mill based the molasses payment on the sugar yield.
Hauling: Four mills based the hauling payment on the gross cane weight. Three mills based the hauling payment on "net" cane as determined above.

Grower Response: The following comments were received on the growers' response to the core sampling system:

Very well - should have been installed many years ago.
Very well on the whole.
Apprehensive at first, then gained confidence in system.
Excellent response.
Satisfied and enthusiastic. Pleased with speed.
Apprehensive at first, then concluded it was fair.
Good acceptance.

Factory Response: Factory personnel provided the following comments on the core sampling system:

Delighted.
Should have been adopted years ago. May not be perfect but is far superior to the old system.
Mud in juice should be deducted. Improve microwave method.
Operation under muddy conditions not encountered. Mud in juice sample measured and corrected for.
Tremendous improvement over old method. Sub-sampler needs improving.

Variability between Factories: The ratio of the actual sugar production to the theoretical recoverable sugar (TRS) predicted by the corer is called the liquidation factor. In 1978 this factor varied from a low of 84% to a high of 95% with an average of 90.5%.

In the case of the conventional sampling method the factory yield per standard ton reflects the variability between factories in much the same way as the variation of the liquidation factor reflects the variability between factories using the corer.

In 1978 the yield per standard ton for those factories using the conventional method varied from 157.1 to 184.8 with an average of 170.7 lb/standard ton.

The variability of the yield per standard between factories using the conventional system was about 40% more than the variability in the liquidation factor for those factories using the core sampler. Variability was measured by the quotient of standard deviation to the average.

CORE SAMPLING METHOD

Data Required:

Bagasse % Cane	(by weighing)
Moisture % Bagasse	(by weighing)
Extracted Juice Brix	(by refractometer)
Extracted Juice Pol	(by polariscope)

Assuming that the extracted juice and the residual juice have the same composition the fiber % bagasse is given by

$$\text{Fiber \% Bagasse} = 100 - \frac{\text{Bagasse \% Moisture}}{(1 - \text{Extracted juice Brix}/100)}$$

Thus the fiber % cane, F, is given by

$$\text{Fiber \% Cane} = F = (\text{Fiber \% Bagasse}) \times (\text{Bagasse \% Cane})/100$$

and the absolute juice % cane is given by

$$\text{Absolute Juice \% Cane} = 100 - \text{Fiber \% Cane}$$

The Brix % Cane can be calculated as follows:

$$\text{Brix \% Cane} = B = (\text{Juice \% Cane}) \times (\text{Brix \% Juice})/100$$

The Pol % Cane can be calculated as follows:

$$\text{Pol \% Cane} = P = (\text{Juice \% Cane}) \times (\text{Pol \% Juice})/100$$

The above expressions allow the Brix, Pol and Fiber percent cane to be calculated. The sugar yield can be obtained from:

Theoretical Sugar Yield, lbs. 96% sugar/gross ton of cane =

$$\frac{2000 \times \text{Pol \% Cane}}{100} \times \frac{\text{Extraction}}{100} \times \frac{\text{Retention}}{100} \times \frac{1}{0.96}$$

The retention is obtained using the Winter-Carp formula and multiplying by the boiling house efficiency (BHE):

$$\text{Retention} = \left[1.4 - \frac{40}{\text{Extracted Juice Purity}}\right] \times \text{BHE}$$

The extraction is obtained assuming a constant reduced extraction with an absolute juice % fiber of 56.67:

$$\text{Pol Extraction} = 100 - \frac{56.67\ (\text{Fiber \% Cane})}{(100 - \text{Fiber \% Cane})}$$

which predicts the following extractions:

Fiber % Cane	Pol Extraction
0	100.00
10	93.70
15	90.00
20	85.83

Substituting the reduced extraction expression developed above for the pol extraction, the Winter-Carp formula for the boiling house retention, and assuming a Boiling House Efficiency of 96, the sugar yield expression reduces to:

$$\text{TRS, lb. } 96^\circ \text{ sugar/gross ton cane} = (0.28P - 0.08B)\left(100 - \frac{56.67F}{100-F}\right)$$

TRS = Theoretical Recoverable Sugar

$$\text{Liquidation Factor} = \frac{\text{Actual Factory Sugar Production}}{\sum \text{TRS}}$$

CRS = TRS x Liquidation Factor

MAINTENANCE STANDARDS FOR SUGAR MILLS

Lawrence Mann, Jr., Professor
Department of Industrial Engineering
Louisiana State University
Baton Rouge, Louisiana

UNIQUENESS OF THE SUGAR MILL OPERATION

The degree to which maintenance management becomes important is directly proportional to the demands made on the equipment which is to be maintained. In the traditional hard-goods industry where there are a number of alternative routes through the plant, maintenance is not so important as in other applications. In the traditional process plant, the capital intensive configuration of the plant and the fact that there is usually only one path through the plant dictates that maintenance is important and receives continuing attention. In the capital intensive plant the fact that the equipment is so expensive relative to the labor dictates that downtime is costly, and sufficient time, effort and funds can be justified to minimize this downtime.

The sugar mill falls within the realm of the process plant and assumes most of the characteristics that process plants exhibit. The traditional chemical plant or refinery unit operates 24 hours a day, 7 days a week continually except during extended turnaround periods. The sugar mill is a slight variation on this theme in that the overhaul or turnaround periods are very extensive and account for most of the year. Nevertheless, when grinding season initially starts, there are outside influences which dictate that the operation continues once it has started in a minimum maintenance and minimum downtime mode. The fact that management wants the plant to operate continuously for an approximately 120 day period without significant downtime indicates that some forethought and planning should be given to maintenance prior to the beginning of the grinding season. This indicates that some amount of planning should go into the maintenance management system.

Some other characteristics of the sugar mill should be emphasized at the outset. Most mills retain the type of equipment that they have over a long period of time, which from the maintenance standpoint offers certain advantages. The fact that the equipment is with us for some time enables us to be aware of the history of that equipment and we are better able to anticipate what maintenance needs are required. Similarly, the task which we perform becomes somewhat repetitive and offers the advantage in that, since they are repetitive, they can be better planned and executed. Further, the fact that the tasks are repetitive enhances our ability to train craftsmen so that the work can be done correctly and expeditiously. A further advantage lies in the fact that we have a better idea of what spares and materials are required so that we might obtain those materials prior to the start of maintenance activities.

Some plants, because they are old, have a difficult time in obtaining spares, and, in some cases, must fabricate their own or go out to suppliers to fabricate the parts which are needed.

WHAT STANDARDS WILL DO

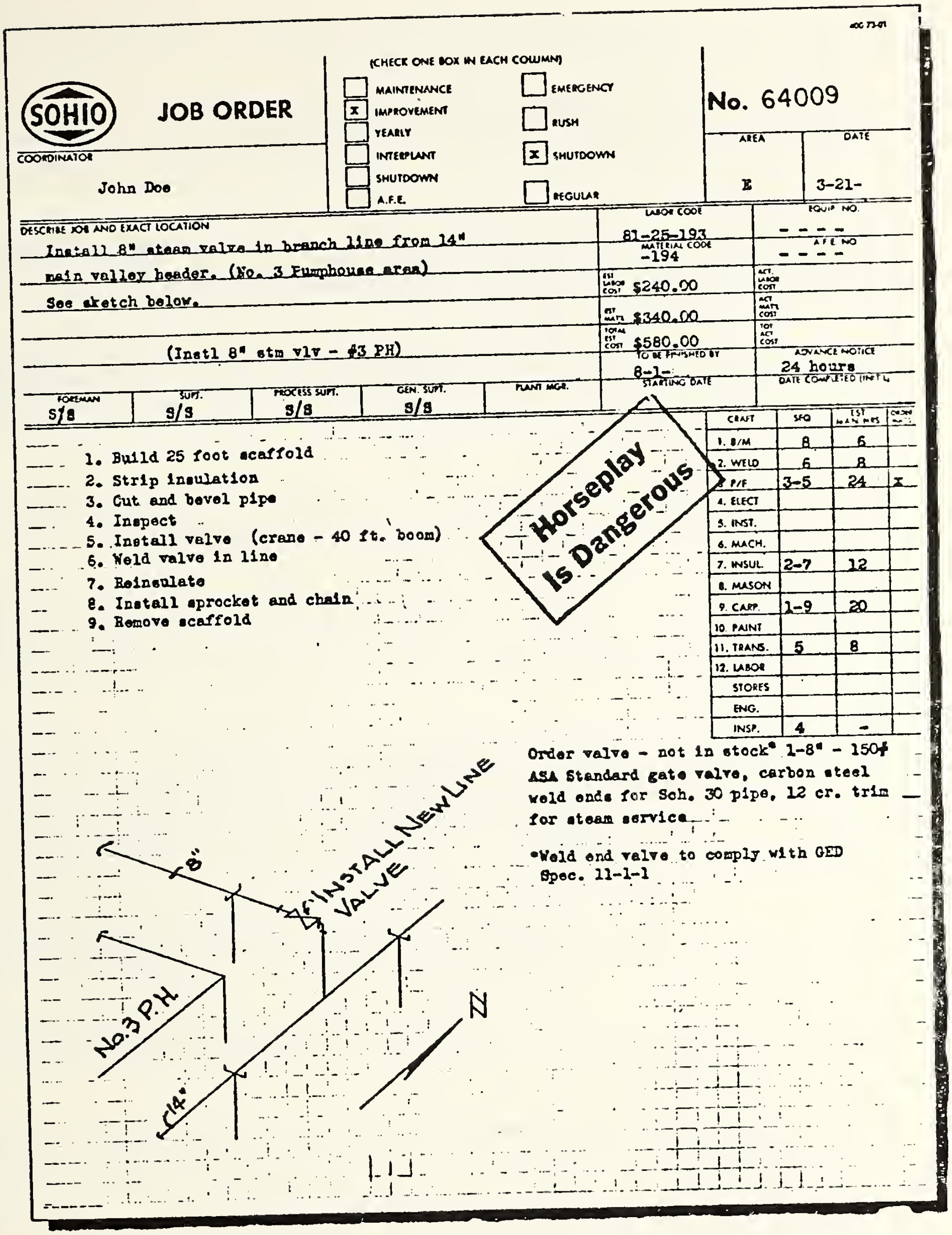
From the standpoint of plant maintenance, standards have a unique definition. An engineering standard is a technological condition described in a document, adoption of which results in compatibility, interchangeability, and acceptability because of its uniformity. The most common definition of a standard is something set up as an approved example.

Standardization is the act of establishing standards, having them agreed to and accepted, and then putting them into practice. Standardization is also the procedure for developing the orderly approach to undertakings in order to achieve optimum economy, safety, and benefits to those employing the standards.

Within these definitions the application of standards to maintenance indicates that the process includes documentation, approval, and repeated use.

Most maintenance standards include four distinct sections. The first section includes the documentation of the steps required to perform the maintenance operation. This documentation not only assures that the work will be done in a logical sequence but also enhances training in that the craftsman has before him the steps that he must take to successfully complete the maintenance work order.

The second portion of any maintenance standard is the list of spare parts and materials which are required to perform the work order. Third, an estimate of the time and crew required to perform the operation is included on the standard. The final inclusion to a standard is the listing of any safety or other requirements which are special to the job in question. Figure 1 indicates such a standard.



SOHIO **JOB ORDER**

COORDINATOR
John Doe

(CHECK ONE BOX IN EACH COLUMN)

☐ MAINTENANCE
☒ IMPROVEMENT
☐ YEARLY
☐ INTERPLANT
☐ SHUTDOWN
☐ A.F.E.

☐ EMERGENCY
☐ RUSH
☒ SHUTDOWN
☐ REGULAR

No. 64009

AREA: E
DATE: 3-21-

DESCRIBE JOB AND EXACT LOCATION
Install 8" steam valve in branch line from 14"
main valley header. (No. 3 Pumphouse area)
See sketch below.

(Instl 8" stm vlv - #3 PH)

LABOR CODE: 81-25-193
MATERIAL CODE: -194
EST LABOR COST: $240.00
EST MAT'L: $340.00
TOTAL EST COST: $580.00
TO BE FINISHED BY: 8-1-
STARTING DATE:

EQUIP NO.: - - - -
A F E NO: - - - -
ACT. LABOR COST:
ACT MAT'L COST:
TOT ACT COST:
ADVANCE NOTICE: 24 hours
DATE COMPLETED (INIT'L)

FOREMAN	SUPT.	PROCESS SUPT.	GEN. SUPT.	PLANT MGR.
S/S	S/S	S/S	S/S	

1. Build 25 foot scaffold
2. Strip insulation
3. Cut and bevel pipe
4. Inspect
5. Install valve (crane - 40 ft. boom)
6. Weld valve in line
7. Reinsulate
8. Install sprocket and chain
9. Remove scaffold

Horseplay Is Dangerous

CRAFT	SFQ	EST MAN HRS	[illegible]
1. B/M	8	6	
2. WELD	6	8	
3. P/F	3-5	24	x
4. ELECT			
5. INST.			
6. MACH.			
7. INSUL.	2-7	12	
8. MASON			
9. CARP.	1-9	20	
10. PAINT			
11. TRANS.	5	8	
12. LABOR			
STORES			
ENG.			
INSP.	4	-	

Order valve - not in stock* 1-8" - 150# ASA Standard gate valve, carbon steel weld ends for Sch. 30 pipe, 12 cr. trim for steam service

*Weld end valve to comply with GED Spec. 11-1-1

Figure 1.

CREATING THE STANDARD

As each maintenance job comes to the maintenance supervisor, he must decide whether the job is sufficiently repetitive to create a standard. If he decides that one should be written, then he must meet with the supervisor who normally does that job and plan the job from the standpoint of the four approaches mentioned above. Once this effort has been accomplished, then the standard is placed in the file and is withdrawn as work orders are required or as the plant overhaul dictates.

The question is often asked as to the extent to which jobs should be standardized. Since the sugar mill is rather static from the standpoint of technology, then more standards should be written than for plants where the technology is changing rather than where the probability of continuing to do the same effort on the same equipment is rather low. Research shows that approximately 50% of the maintenance manhours spent for all process industry are planned or standardized to some extent. It appears from the nature of the sugar mill that perhaps a greater percentage of work done is adaptable to standardization than for the normal process plant.

BASIC ADVANTAGES OF MAINTENANCE STANDARDS

There are ten basic advantages to using engineered standards for management control. They are as follows:

1. Consistent estimating. Since all maintenance planners are using the same standard data for estimating job content, the man-hours required for various maintenance jobs will be consistent. Proposed expenditures can be evaluated with some assurance of reliability, and performance by individuals or by craft can be measured accurately with assurance of reliability.

2. Methods analysis. One of the maintenance planner's functions is to evaluate a job before it is started. Alternate methods of installation can be properly weighed and compared. Decisions can be made as to whether jobs should be contracted, prefabricated, or performed by maintenance personnel with assurance of obtaining predicted results. The need for improved facilities can be emphasized since handicaps which exist from a physical facility standpoint must be allowed for in planning the labor content of a particular job.

3. Elimination of delays through improved scheduling. Since the time duration of a job can be predicted, the maintenance planner and the maintenance supervisor are aware of the start and finish point for each job. This eliminates the delays brought about by inaccurate estimating and results in reduced labor costs through improved effectiveness.

4. Coordination of crafts. In the event that two or more crafts are involved in a particular job, it is necessary to coordinate the start and stop times of each craft in order to avoid a craft's arriving too early or too late. Determination of labor content for each craft provides for proper coordination between supervisors because the planners advise them in advance of their particular assignments.

5. Improved supervisory controls. When almost all of the paperwork involved in maintenance is done by the planner, the supervisor has additional time to spend on the job. Supervisors are selected for job knowledge and for their ability to control personnel. Time spent on paperwork detracts from these very important responsibilities. Also significant is the fact that because the jobs are consistently estimated, the supervisor has an additional control tool to use in directing his people. Accountability for improper performance is made possible when he is equipped with a realistic estimate of the labor time required to complete a particular assignment.

6. Training. The maintenance control program results in training planners in the techniques of supervision and management. The planners, who could ultimately become craft supervisors, receive invaluable training as preparation for future promotions. Inadequate training of craftsmen is also brought to light through the application of proper job-content estimates.

7. Materials control. The maintenance planner, in addition to controlling labor content, contributes to the control of materials. Jobs should not be scheduled unless the materials are available and on hand so that work can be started. Materials costs are assembled in addition to labor costs on each job.

8. Work backlog control. Since maintenance work which can be planned in advance is estimated with regard to labor content, the work backlog for each craft can be controlled. Through application of standards and proper estimating, the backlogs can be managed and adjusted as required.

9. Controlled manning. Proper data are available to supervisors and management, and decisions are made so that the fluctuations in maintenance requirements are handled properly. Personnel transfers or replacements are planned, and the volume of work done by outside contractors is managed.

10. Cost control. The end result of the program is in maintenance cost control. Management is informed of actual maintenance costs and standard maintenance costs and is given a basis for accurately evaluating, forecasting, and controlling maintenance expenditures.

DO MAINTENANCE STANDARDS WORK?

Will maintenance standards do anything for you? Will they help you cut maintenance costs? Better find out. Current performance is our best clue. If your current work performance is low and if you feel that there is a lot of idle time consumed by your highly paid craftsmen, then you better take some action to minimize this idle time.

Where maintenance standards work, the pickings are good. Direct savings will run from 10 to 35% of maintenance labor costs to which you may add indirect benefits from decreased downtime. But remember that any program such as we are discussing here must have the wholehearted backing of management and the supervision who will perform a maintenance activity. It will certainly pay you to discuss these matters with all of your supervisory employees before you attempt to establish any kind of a maintenance standards program.

Another advantage in the maintenance standards program lies in the fact that you can move at your own pace. This does not particularly require that you expend appreciable efforts during any time period, but can ignore the creation of the standards during rush periods and return to this activity when you have time.

In summary, most plants which have embarked upon a maintenance standards program have realized real savings from the program and certainly the efforts have minimized the headaches for management whose responsibility is maintaining the plant.

FIBER CONTENT OF LOUISIANA SUGARCANE VARIETIES USING THE CUTTER-GRINDER-PRESS METHOD OF CANE ANALYSIS

C. A. Richard[1/]
American Sugarcane League

ABSTRACT

Varietal fiber content determined by the press method of cane analysis was compared to varietal fiber content previously determined by a conventional method. There was good agreement between these methods of determining fiber on commercially grown varieties with a correlation coefficient of .87**. Current trends in fiber content of several recent series of selections revealed increasing fiber levels. Using data from the press method only, the association between fiber content in different years as well as associations between individual replications of any one year and the average fiber content of two years were strong. The data indicated that selection for fiber content by the press method was relatively easy and accurate and screening for unacceptable fiber might be accomplished at an early selection stage.

INTRODUCTION

Acceptable fiber content is an essential consideration in the genetic engineering of maximum sugar production. However, screening for this important trait in Louisiana is not begun until the sixth year (Infield stage) of the selection program. At this stage of selection there are usually less than 50 clones remaining in the testing program (Table 1). Thus, screening at this stage is of concern since considerable time and effort have been invested in clones that may have to be discarded due to an undesirable level of fiber. Further, this routine at this selection stage does not usually allow for replacement clones which may have a more acceptable level of fiber. Since the present method of determining fiber (4) requires more cane than can be supplied at an earlier stage in the selection program, a different method of analysis should be contemplated.

Table 1. General scheme of the Louisiana sugarcane breeding programs at the Louisiana State University Agricultural Experiment Station and at the US Sugarcane Field Laboratory.

Selection Stage	Number of Units
Single stool stage	40,000 - 100,000
First line trials	4,000 - 10,000
Second line trials	1,000 - 5,000
Assignment candidates	100 - 200
Permanent assignments	50 - 100
Infield tests (3 years)	75 decreased to 20
Outfield tests (3 years)	20 decreased to possible release of variety

Daubert (1), Savage (7), and Norris (6) among others, during the early 1900's, experimented with several methods for determining fiber content. However, none of these methods proved to be practical. Hebert and James (2) reported on work with three methods for determining fiber. The simplest method involved using a washing machine to leach residual soluble solids from bagged samples of bagasse and took two hours of washing time and several days to dry remaining fiber to constant weight. Henderson et al. (3) reported on a simple technique for estimating fiber content at the LSU Experiment Station which included single mill passes, bagging stalk remnants and drying them for fiber estimates. This method has not been used in the variety selection program but has been used successfully in genetic studies and in programs elsewhere.

Tanimoto (8) described a rapid method for estimating fiber percent cane using a cutter-grinder-press method. In addition to fiber content, other cane quality information was obtained. This method has been used successfully in Hawaii to determine cane quality due to differences in crop age, variety, fertilization, and

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[1/] The work reported herein was conducted while employed by the Louisiana Agricultural Experiment Station.

climatic conditions. The cutter-grinder-press method seems to offer advantages in fiber determinations. Therefore, tests were conducted in 1975 and 1976 to evaluate the procedure as a possible screening technique for fiber content for the Louisiana variety selection programs.

MATERIALS AND METHODS

Plant cane grown at the St. Gabriel Farm of the Louisiana Agricultural Experiment Station were used for this series of experiments. During October 21-27, 1975, and on October 29, 1976, three replications of the nine commercial and 26 experimental varieties shown in Table 2 were cut by hand, stripped, and brought to the laboratory for analysis.

Each sample consisted of six stalks and was ground in a Jeffco Cutter-Grinder, Model 265 BM. After thoroughly mixing the prepared material, a 750 gram subsample was placed in the cage of a Model C Carver Press and pressed at 18,000 lb. pressure, equivalent to 2546 psi. The expressed juice was then analyzed for brix using a spindle hydrometer and for sucrose using Horne's method. The pressed residue was weighed, dried in a forced air oven at 130° F. until constant weight was reached, then reweighed to give dry weight. The fiber content of each sample was calculated from the data collected as described by Tanimoto (8). The data was compared to fiber determined by the conventional method from two to ten tests or more at the US Sugarcane Field Laboratory in Houma, Louisiana (5). This method utilizes 80-lb. samples which are milled by multiple passes through a three-roller mill. Subsamples are weighed, leached of residual soluble solids and dried to constant weight to determine fiber percent bagasse. Fiber percent cane is the product of bagasse percent cane times fiber percent bagasse.

Fiber data for all varieties were analyzed by individual harvest date and as an average of both harvest dates. The HSD (.05 P) test of significance was used to determine significant differences between the fiber content of different varieties. Associations were measured between fiber content and years, between the press method and the conventional method of determining fiber content, and between individual replications and an average of both harvests. For each harvest the commercial variety CP 65-357 was considered the standard variety.

RESULTS AND DISCUSSION

The tests of significance for varieties in individual harvests indicated significant differences among varieties previously shown to be different in fiber content (5). A "t" test indicated the two harvests were not significantly different in average fiber content. A combined analysis of these two harvests as shown in Table 2 indicated significant differences among varieties known to be different in fiber content.

Table 2. Combined analysis of fiber percent of nine commercial and 26 experimental varieties during 1975 and 1976 harvests.

Commercial varieties	Experimental varieties	Fiber percent cane
	L 72-92	15.9
	L 72-33	15.1
	L 72-17	13.9
	L 72-62, CP 70-330	13.6
CP 67-412	CP 71-371	13.0
	L 71-20, CP 70-401	12.8
CP 65-357, CP 52-68	CP 71-318, L 72-35	12.6
	L 72-9	12.5
L 65-69		12.2
	L 72-1, L 72-47	12.1
L 62-96		11.9
	CP 71-326, CP 71-380	11.8
	L 72-3	11.7
	L 72-85	11.6
	L 70-16	11.5
	CP 70-321, L 71-94	11.4
	L 61-67	11.3
	L 70-65	11.2
L 60-25		11.0
	CP 70-300, L 71-29	10.9
CP 48-103		10.7
	L 70-30	10.6
NCo 310		10.5
CP 61-37		10.3
HSD (.05 P)		0.9

Significant fiber differences from the press method among the commercial varieties as shown in Table 2 clearly demonstrate the concern for high fiber in our current breeding programs. Although the varieties are ranked in descending order of their fiber content, the order of commercial varieties approaches a chronological listing. Only CP 52-68 and CP 61-37 are ranked improperly according to their date of release.

To further demonstrate this point, compare the average fiber percent cane of all nine commercial varieties to the average fiber percent cane of each breeding series. The average fiber content for the nine commercial varieties, the 1961 series variety and the seven 1970 series varieties was 11.7, 11.3, and 11.6%, respectively. However, the average fiber content for the seven 1971 series varieties and the eleven 1972 series varieties was 12.0 and 13.0%, respectively. This would indicate that the average fiber content of both released and experimental varieties has increased even though it has been monitored during the selection programs.

Fiber data from the conventional method of fiber determination from the US Sugarcane Field Laboratory was available on 28 of the 35 varieties evaluated in this series of experiments. The fiber contents of these 28 varieties measured by the press method were compared to fiber contents measured by the conventional method and a scatter diagram of these data points is shown in Figure 1. All data points for the press method of fiber determination are an average of two tests while the data points for the conventional method are a result of varying numbers of tests from different years. For this reason, two correlation coefficients and regression lines are shown.

The correlation coefficient of .87** occurred between the two fiber determination methods when only nine commercial varieties were included. For these nine varieties there was an average of 27 (range of 6 to 135) tests per variety from the conventional method. It should be noted that because of this strong association the simple technique of the press method provided fiber data similar to data obtained from extensive milling tests of the conventional method.

The correlation coefficient of .48* occurred between the two fiber determination methods when all 28 varieties were included. The 19 additional varieties not included in the first correlation coefficient had an average of seven (range of 2 to 9) tests per variety from the conventional method.

The lower association from the 28 varieties as compared to the association from only the nine commercial varieties was due to a total lack of agreement in only a small number of varieties. These few varieties had from 2 to 8 tests from the conventional method. The low association between the two methods involving all 28 varieties might be due to relatively little fiber data from the conventional method as a result of variety X year or variety X location interactions. It should be noted that for varieties with sufficient data from the conventional method there was good agreement between the press method and the conventional method of determining fiber.

Correlation coefficients between individual replications and the mean of all replications averaged .86** for all harvests in the press method. This shows the possibility of using small numbers of replications, possibly single reps, as a screening procedure. Resampling of suspected high fiber varieties to conclude their acceptability or rejection might follow this technique. Further evidence of the reliability of this data would be the average coefficient of variation of 4.0% for the two harvests.

The procedure has shown its accuracy in determining fiber content, but it can also be shown that use of this procedure can increase the speed of sampling. Current conventional fiber determinations allow for a maximum of 36 samples per day. Samples must then be washed and dried. With the cutter-grinder-press method it has been possible to run up to 75 samples per eight hour day with no washing time required. With further improvements in the equipment used with this method it may be possible to increase this figure to 100 samples per day.

Data on the breeding series used in these experiments indicate the need for an immediate selection routine in as early a selection stage as possible in both Louisiana breeding programs. Although the data is limited, it might indicate that this routine could be used with some effectiveness in an earlier stage than is now practiced. This procedure could be used when the number of varieties for testing has been reduced sufficiently to allow time for this fiber determination method. As seen in Table 1, our current breeding programs have approximately 100 to 200 candidates for assignment of permanent variety numbers from which 50 to 100 are chosen and advanced to infield trials. If future research proves this method to be of practical use, then the screening for high fiber content could be moved to this phase of the program and all varieties excessively high in fiber could be replaced before yield tests are conducted on a replicated basis. Varieties marginal in fiber content would probably be assigned a permanent number and monitored during the program for fiber content. Care must be taken not to eliminate varieties which may be somewhat marginal in fiber content yet superior in yield of recoverable sugar per ton of cane. This information can be obtained with the press method of cane analysis. In the event of total yield of biomass becoming a selection

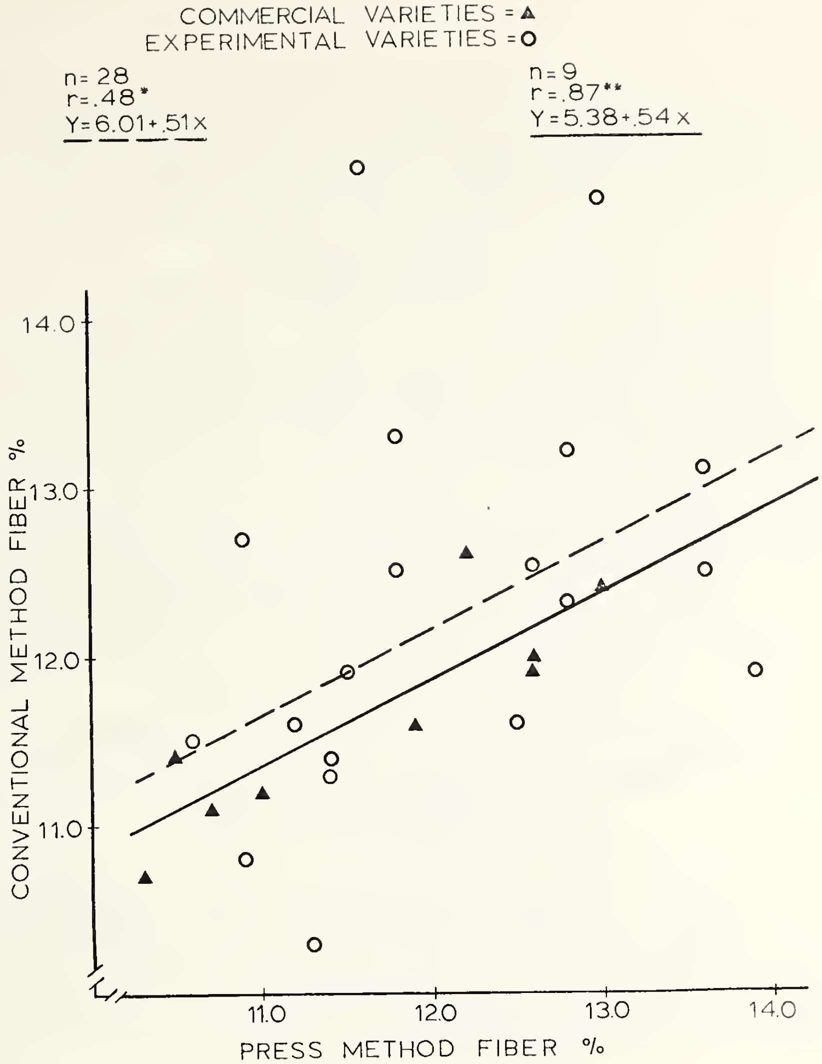

Figure 1. Relationship of the conventional method to the cutter-grinder-press method of determining fiber content of sugarcane. The solid regression line compares the two methods of only the nine commercial varieties while the dashed regression line includes all 28 varieties.

criterion, this method could be used with the same success since this data would be just as reliable for selection of high fiber varieties as it is for low fiber varieties.

ACKNOWLEDGMENTS

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ABSTRACTS - AGRICULTURE

ECONOMIC THRESHOLDS FOR SUGAR CANE BORER POPULATIONS IN FLORIDA

Josev Alvarez and Gerald Kidder
Area Economist and Extension Sugar Cane Specialist
University of Florida
Agricultural Research and Education Center
Belle Glade, Florida

The sugar cane borer, Diatraea saccharalis (F.), is one of the most destructive insects attacking sugar cane in the continental United States, and treating the plants with insecticides has been recommended for controlling sugar cane borer populations. A five percent level of infestation has been set in Louisiana and Florida as the point at which treatment becomes necessary. However, a fixed limit cannot cover all possible situations. The study applies and expands a previously advanced definition of the economic threshold. It is defined as dependent upon time, yield and prices.

Economic thresholds are calculated for the Florida situation using three levels of yield, three prices of sugar per pound, and three times in the season. Results show the economic threshold values decreasing as yields and prices of sugar increase, but increasing as the season advances. They range from a low 2.7 percent early in the season for a 45-tonne field when the price of sugar is US $0.15 per pound, to a high 13.4 percent late in the season for a 20-tonne field when the price of sugar is $0.12 per pound. Results also indicate the importance of considering all factors involved when computing economic thresholds, since they usually result in reduced insecticide treatments.

MIDWESTERN CULTIVATION OF SWEET SORGHUM AS A RENEWABLE ENERGY CROP

M. F. Arthur, D. R. Jackson, S. Kresovich and W. T. Lawhon
Battelle Columbus Laboratories
Columbus, Ohio

The rising cost of petroleum has necessitated research into practical alternative sources of energy, including solar energy. Obvious, but often overlooked, solar converters are green plants. The objective of this research was to determine the feasibility of large-scale sweet sorghum production as a renewable source of ethanol. The sugars produced during the growth of the plant may be fermented into ethanol and mixed with gasoline to produce gasohol. Such a development could help offset the growing U.S. dependency on foreign oil supplies. The results of this research indicated that sweet sorghum may be grown in the midwestern U.S. with yields comparable to those obtained in southern states where sweet sorghum traditionally has been grown for syrup production.

YIELD COMPONENTS IN THE F_1 AND BACKCROSS GENERATIONS OF SACCHARUM SPONTANEUM (US 56-15-8) WITH COMMERCIAL HYBRIDS

R. D. Breaux
USDA, Science and Education Administration
Houma, Louisiana (in cooperation with the
Louisiana Agricultural Experiment Station)

A study was conducted to measure the effect on quantitative yield components when S. spontaneum is crossed and backcrossed to commercial hybrids. The mean yield of tonnes of cane per hectare was very high in the F_1 generation but dropped drastically with backcrossing. The mean yield of kg sugar per tonne of cane was very low in the F_1 generation and increased significantly with backcrossing. The mean yield of sugar per hectare was lowest in the F_1 and BC_1 generations, significantly lower than the commercial control cross. The data indicate that US 56-15-8 could reach a commercial level for yield with two to three backcrosses to commercial hybrids.

BREEDING BEHAVIOR OF STUBBLING ABILITY IN SUGAR CANE --PRELIMINARY OBSERVATIONS

John W. Dunckelman and M. T. Henderson
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

A study was conducted to determine the breeding behavior of stubbling ability in sugar cane from the plant cane crop through 2nd stubble. Two-hundred and ten clones, chosen at random from the progeny of a cross of CP 65-357 x L 65-69 comprised the experimental units with each being planted to a 10-foot clonal plot. Five replicates of each parental clone were incorporated in the experiment as checks. The characteristics studied as indicators of stubbling ability were stalk population, stalk weight, stalk length, stalk diameter and plot yield, calculated as the product of clonal population x average clonal stalk weight. Sucrose content was also determined through polarimetry and Brix analysis. The sample size

used was 20 stalks per clonal plot. This paper is a preliminary investigation of the plant cane and first stubble crops. The mean characteristics for the experimental clones within separate years were as follows. Plant cane: population, 53.9 stalks/plot; weight, 0.923 kg/stalk; length, 2.02 m/stalk; diameter, 22.7 mm/stalk; yield, 49.35 kg/plot. First stubble: population, 60.1 stalks/plot; weight, 0.851 kg/stalk; length, 2.28 m/stalk; diameter, 21.5 mm/stalk; yield, 50.65 kg/plot.

A REPORT ON THE SUGAR CANE TECHNOLOGY PROGRAM AND THE CANE SUGAR REFINERS SHORT COURSE AT NICHOLLS STATE UNIVERSITY

Robert N. Falgout
Nicholls State University
Thibodaux, Louisiana

Three years ago, Nicholls State University began a two-year Associate of Science Degree program in Sugar Cane Technology, offering options in either processing or production. The overall goal of the program has been to develop qualified mid-management level personnel for the sugar industry. To date, nine students have completed the requirements, with four more scheduled to graduate this semester. An additional seven students are planning to finish either this summer or after the 1979 fall semester. Of those already graduated, three have elected to continue their education at Nicholls, while the remaining six students are now working in fields or factories where the demand for their services still remains very high.

In July, 1978, Nicholls State University conducted its First Annual Cane Sugar Refiners Short Course. Its purpose was to provide short-term training for engineers, technicians and management personnel in the cane sugar refining industry. The objectives were: to promote training which will upgrade the skills of participants making them better employees; to provide background knowledge, so that participants will be better prepared to assume positions of responsibility and leadership; and to develop in the participants an appreciation for the total operation of the plant. The format was a two-week intensive learning situation with some topics being covered by full-day sessions and some by half-day sessions. Classes included lectures and discussions, with many informal sessions during "out-of-class" hours.

Some 29 participants from all over the world completed the short course. The reaction from both students and teachers was overwhelmingly favorable. Response was so good that the University is planning a similar short course.

RUST DISEASE IN GUATEMALA

Alfonso L. Fors
International Sugar Cane Consultants, Inc.

Cane sugar is an important export commodity in Guatemala, so any given condition jeopardizing sugar cane production creates a certain degree of alarm among cane farmers and sugar producers. Less than three months ago, the presence of sugar cane rust disease (Puccinia spp.) was confirmed in the eastern coastal cane belt, mainly affecting variety B 4362. Outside of Mexico, this is the first Central American country where rust has been found. This paper points out the effect of the disease in one of the most important commercial varieties in Guatemala. Also included are field and laboratory observations, suggested methods of control and notes on the discovery of rust in an experimental variety: Cl 61-5.

THE ROLE OF SUGAR CROPS IN SUPPLYING NEW FUEL RESOURCES IN THE U.S.

D. R. Jackson, S. Kresovich and W. T. Lawhon
Battelle Columbus Laboratories, Columbus, Ohio

Recent increases in OPEC oil prices emphasize the need for alternate fuel sources in the U.S. Conversion of sugar crops to fuel-grade alcohol can provide a significant contribution to the national economy. An additional incentive for this option is to raise net farm income by providing new cash crops. Results from an ongoing FUELS FROM BIOMASS Program, sponsored by the U.S. Department of Energy, indicate the yield potential to be derived from sugar cane and sweet sorghum. Sweet sorghum has responded well to intensive cultivation and has a wide geographic potential.

MATURITY STUDIES OF COMMERCIAL SUGAR CANE VARIETIES IN LOUISIANA

B. L. Legendre
U.S. Sugar Cane Field Laboratory, USDA
Science and Education Administration
Houma, Louisiana (in cooperation with the
Louisiana Agricultural Station)

The relative maturity of nine varieties of sugar cane was compared over five years (1974-1978) in first-stubble crops at the U.S. Sugar Cane Field Laboratory, Houma, Louisiana. The study revealed important varietal differences in the normal juice sucrose (NJS) and purity (NJP) during the harvest period, which usually begins in October and ends in December. The early maturing, high-sucrose varieties, such as L 60-25, and, to a lesser extent, L 62-96 and L 65-69, reached standard NJS (12 percent) and NJP (76 percent) by October 15; thereafter, NJS and NJP increased slowly. Other varieties, like CP 65-357, the most important commercial variety in the state, and CP 48-103, approached standard NJS and NJP by mid-October, but continued to accumulate sucrose and mature throughout the harvest period. Usually, CP 65-357 surpassed all varieties in NJS and NJP by December 1. The late-maturing varieties, CP 52-68, CP 61-37, CP 67-412 and NCo 310, had very low levels of sucrose early in the harvest season and they generally did not exceed standard NJS and NJP until mid-November. The pattern of ripening in these different varieties appeared to be fairly constant despite large variations in temperature and rainfall during the harvest period of the study duration.

PANEL DISCUSSION - ALCOHOL FOR FUELS

Joseph A. Polack, Carlos R. Toca, Joseph R. Orsenigo, and Joseph A. Harrison
Audubon Sugar Institute, Louisiana Agri-Fuels Corp., Florida Sugar Cane League, Inc.
and Supreme Sugar Company, Inc., subsidiary of Archer-Daniels-Midland

The panel discussed the current status of planning in Louisiana and Florida for the production of fuel alcohol from cane juice, molasses and other renewable resources. Technical, economic and legislative political aspects were considered. Questions from the floor were invited.

SWEET SORGHUM FOR SUGAR AND BIOMASS PRODUCTION IN LOUISIANA

R. Ricaud, B. Cochran, G. Newton and A. Arceneaux
Louisiana Agricultural Experiment Station
Baton Rouge, Louisiana

Experiments have been conducted to determine the effects of methods of planting two varieties of sweet sorghum (Sorghum bicolor) on the yield of sugar and biomass for potential use in alcohol production. Rio and Wray varieties were planted using two-drill and broadcast methods in 1977 and using one-, two-, three-drill and broadcast methods in 1978 on rows six feet wide. The sorghum was planted in April and harvested in late August with a combine chopper harvester in 1977 and a soldier type sugar cane harvester in 1978.

In 1977, the average stalk populations were 102,000 and 160,000 per hectare and the average stalk yields were 61.2 tonnes and 59 tonnes per hectare with the two-drill and broadcast methods, respectively. The average stalk yields were 53.1 tonnes and 67.1 tonnes per hectare and total plant or biomass yields were 74 tonnes per hectare with Rio and Wray varieties,respectively. Rio contained 14.4% sucrose with 87.3% purity and Wray contained 14.1% sucrose with 81.0% purity in the juice at harvest time.

In 1978, stalk populations ranging from 30,250 to 154,000 per hectare produced maximum yields of 44.8 tonnes of stalks or 55.6 tonnes of biomass per hectare with Rio and 56.7 tonnes of stalks or 78.8 tonnes of biomass per hectare with the Wray variety. Rio contained 12.9% sucrose and 78.4% purity in the juice at harvest time.

Processing studies were made each year at the Audubon Sugar Institute in cooperation with personnel in the Chemical Engineering Department at LSU and USDA-ARS Food Crops Utilization Research at Weslaco, Texas.

USE OF AERATED STEAM FOR CONTROL OF SOME DISEASES OF SUGAR CANE IN LOUISIANA

R. J. Steib
Department of Plant Pathology and Crop Physiology
Louisiana Agricultural Experiment Station
Louisiana State University, Baton Rouge, Louisiana

Initial studies to determine if aerated steam (AS) thermotherapy would be effective for control of sugar cane diseases in Louisiana were undertaken in 1974. Control of ratoon stunting disease (RSD) was found to be possible by treating seed cane with all adhering trash for a period of four hours at 53° C. Using a larger oven than that used in Louisiana (2.25 tonnes), RSD was controlled with 54° C., four hours under tropical conditions.

Aerated steam does not reduce germination of seed cane, as do other heat treatments which are used to control RSD. Treatments made in 1976 to control sugar cane mosaic, which is caused by a virus, included 56° C.-2.5 hour and 57° C-2.0 hour methods. A high degree of mosaic control was obtained; however, the germination of varieties sensitive to AS was reduced to a low level. The uncontrolled volume of steam entering the oven resulted in a very rapid rise in the treatment temperature desired within 20 to 30 minutes. Apparently, the hot steam scalded the tender buds on the four to five month old seed cane used for planting in Louisiana.

In order to reduce damage by the hot steam, a number of factors needed to be stabilized. Tests were made to establish the following parameters: the steam pressure and volume of steam entering the oven for different temperature-time combinations for given volumes of cane; the effect of the ambient temperature of the cane mass on the rate of temperature rise in the oven at different steam pressures and inlet volumes; and the effect of different methods of loading the oven on temperature distribution in the oven and on the rate of temperature rise in the cane mass throughout the oven.

Tests made in 1977 using 56°-3.0 hour treatments with reduced volumes of inlet AS were found to delay the temperature rise in the oven by 1.25 to 1.50 hours. The steam pressure was maintained between 25 and 45 psi for these tests, as they were for treatments made the previous year. The reduced inlet volume, which prevented the quick temperature rise, resulted in excellent germination for all varieties treated at 56° C. -three hours; RSD was effectively controlled. Even though the seed cane temperature was at 56° C. during the last 1.5 to 1.75 hours of the treatment, mosaic was not effectively controlled. For all 15 tests made the following year (1978), the steam pressure was controlled at either 10 or 15 psi and the volume of steam entering the oven regulated using four or six holes of 0.1625-inch diameter made in the steam inlet pipe. The treatments included temperature-time combinations of 56° C. and 4.0, 4.5 and 5.0 hours. These tests resulted in acceptable germination for only the most heat-resistant varieties. Average mosaic control for the 4.0 and 4.5-hour treatments at 56° C. was 66.7 percent, respectively. The desired in-cane temperature was reached after 2.0 to 2.5 hours of the four-hour treatment period.

Results of the tests made during the past two years indicate it may be possible to control sugar cane mosaic in only the most heat-resistant varieties with only one AS treatment, if most parameters known to affect the results obtained from the AS treatment system are controlled. It was also concluded that it may be possible to control mosaic in the more heat-sensitive varieties using a slightly higher steam pressure and slightly greater inlet volume, along with a shorter treatment period.

ABSTRACTS - MANUFACTURING

DEVELOPMENT OF AN EFFECTIVE CHEMICAL CLEANING PROCEDURE FOR STEAM/VAPOR SIDE FOULING IN HEAT-TRANSFER EQUIPMENT

Pedro R. Arellano, James C. P. Chen and James S. Rauh
Sugar Industry Division, Olin Water Services
Olin Corporation, Overland Park, Kansas

Scale deposition on heat-transfer surfaces, especially evaporator tubes, can directly affect operating efficiencies and, thus, have a direct impact on operating costs in sugar production. Field studies and evaluations of chemical inhibitors and chemical cleaning procedures for controlling or removing scale deposits have been the subject of many technical articles and presentations. The bulk of this information has been involved solely with scale deposition on the juice side.

This paper discusses the importance of scale deposition and steam/vapor side fouling in relation to the overall efficiency of evaporators and other heat-transfer equipment. Steam/vapor side fouling is detailed in information covering its causes, sources of contaminants in deposits, and a review of prior methods attempted to remove such deposits. Also covered is the development of a chemical cleaning procedure from laboratory evaluations through an actual Florida mill application.

INCREASING PROFITS THROUGH MORE EFFECTIVE USE OF PEOPLE AND EQUIPMENT

Wiley M. Morse, P. E.
Morse & Associates, Beachwood, Ohio

This presentation discussed opportunities for increasing profits by improving harvesting and transportation methods. More effective utilization of the agricultural resources of capital equipment and labor was stressed. A case study was presented in which significant opportunities were identified to improve harvesting operations, reduce transportation costs and increase product quality and yield.

TRACE METAL IN SUGAR CANE JUICE - A NEW ATOMIC ABSORPTION METHOD

Luis E. Vidauretta and Carl J. Feigel
Chemistry Department
Louisiana State University, Baton Rouge, Louisiana

A method has been developed for the analysis of trace metals in the various stages of raw sugar refinement. The method includes ashing and filtering states, followed by an analysis of the metals by atomic absorption. The newly developed method is used primarily for very viscous sugar samples.

A COMPUTER SIMULATION STUDY OF MULTIPLE-EFFECT EVAPORATOR CONTROL SYSTEMS

Chien Wang and Adrian E. Johnson, Jr.
Louisiana State University, Baton Rouge, Louisiana

A digital computer model was developed for simulation of multiple-effect sugar evaporators and their control systems. A primary interest in the development of the model was to provide for study of systems in which vapor bleeds are removed from one or more evaporator bodies to supply low-cost heat for other mill equipment. In addition, the computer model was to be flexible and easily modifiable for studying a variety of evaporator configurations and control systems arrangements.

After verification of the computer model by comparing its output with steady-state evaporator design results and with expected dynamic behavior of commercial evaporator systems, a series of case studies were performed to study the effectiveness of conventional control systems in the face of varying vapor bleed demands and other system disturbances. The objective of these studies was to try to identify those situations and configurations which do not provide satisfactory performance. Since extensive vapor bleeding is relatively new to the industry and will probably be used in most new installations to save energy, this study was considered timely.

This paper presents in graphical form the results of the studies made to date, which consist of six different commercial designs, involving various combinations of total number of bodies, number and quantity of vapor bleed streams, and conventional control system arrangements. Some of the conclusions to be discussed are: (1) Systems with pre-evaporators control the pressure of the vapor bleed stream best; (2) whenever too large a vapor bleed stream is removed from the pre-evaporator, the system cannot respond well to large feed rate changes; (3) whenever vapor bleed demands vary (such as the demand from vacuum pans), substantial makeup exhaust steam control action is required even with a pre-evaporator. These and other conclusions and observations are presented in this paper. Future studies are planned to test modifications and innovations to conventional control systems designed to improve the control system performance of evaporator systems providing vapor bleed streams.

(This work represents the results of the M.S. research of Mr. Chien Wang at the LSU Department of Chemical Engineering. Mr. Wang received a grant through the Audubon Sugar Institute from F.C. Schafer & Associates to support him while he fulfilled the requirements for the M.S. degree.)

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